DCS Corporation

FINAL REPORT

DCS-SBIR-97-3106

Development Of A Night Driving Training Aid Concept

Small Business Innovation Research (SBIR) Phase I A96-176a

Prepared for:

Contract No: M67004-97-C-0003
U.S. Army Simulation, Training
and Instrumentation Command
12350 Research Parkway
Orlando, FL 32826-3276

Reporting Period: October 1996 - May 1997

Prepared by:

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Alexandria, VA 22193

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Report developed under SBIR contract. The use of night vision devices (NVDs) by U.S. Army foot soldiers, aviators, and drivers of combat and tactical wheeled vehicles has enhanced operations at night by allowing increased mobility and potentially safer operations. With this increased capability in the night environment has come an increased exposure to the hazards of that environment. Numerous vehicular accidents have occurred during night field exercises involving drivers wearing image intensification (I^2) systems. These accidents can frequently be attributed to perceptual problems experienced by the drivers. Performance with NVDs generally increases with practice and experience. However, there is little formal training provided in night driving skills and few opportunities to practice these skills under realistic conditions. This report documents the approach and results of a Phase I SBIR effort to define and demonstrate a low-cost Night Driving Training Aid (NDTA) concept for training night driving skills with I^2 devices and to identify and evaluate the techniques and resources that are available for implementing this approach. The Phase I findings support the need for and the technical feasibility of an NDTA. Potential training delivery platforms for NDTA development are identified and evaluated.

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Introduction

Night vision devices (NVDs), including image intensification (I^2) and infrared (IR) devices, are being used in increasing numbers by dismounted soldiers, aviators, and drivers of combat and tactical wheeled vehicles. The use of NVDs has resulted in enhanced operations, increased mobility, and potentially safer operations. With increased capability in the night environment has come a higher exposure to the hazards of that environment and the risks that the command structure must manage and balance with mission requirements. A review of accidents involving Army drivers using I^2 devices and the results of experiments conducted by the U.S. Army Dismounted Battlespace Battle Lab (DBBL) at Fort Benning suggest that many of the problems drivers are experiencing are due to perceptual errors. In addition, there is evidence that skills using I^2 devices are highly perishable but improve with practice.

The DBBL, the project sponsor, identified a need for an innovative, low-cost, effective, and interactive night driving training device/simulation concept to train drivers of wheeled and tracked vehicles to drive safely and effectively with Night Vision Goggles (NVGs). In response to SBIR solicitation Number A96-176a, issued by the U.S. Army Simulation, Training and Instrumentation Command (STRICOM), DCS Corporation conducted a Phase I study to develop and assess the feasibility of a night driving training aid concept. The original SBIR solicitation called for the development of a night driving simulator concept. However, discussions with the project sponsor during Phase I indicated that a training aid rather than a simulator is more consistent with the expressed needs and expectations of the end user and the Director of Training Developments at the U.S. Army Infantry School at Fort Benning. Accordingly, the product to be developed in Phase II is referred to as the Night Driving Training Aid (NDTA).

Summary

The objectives of Phase I were to (a) explore concepts and design possibilities, (b) develop concepts for each of the relevant design possibilities, and (3) assess the feasibility for each concept developed. During Phase I, DCS reviewed technical literature on NVG training technology as well as manuals and driver training documents; conducted an analysis of the U.S. Army data base on ground vehicle accidents involving night vision devices; and interviewed NVG training subject matter experts (SMEs) and operational NVG driving training personnel from the 2nd Brigade, 82nd Airborne Division, Fort Bragg, North Carolina. DCS identified training objectives for the NDTA, explored a variety of training/simulation concepts and designs, identified NDTA tasks and training requirements, developed a partial NDTA Concept Development Tool, and determined the top-level functional requirements for the development of a NDTA in Phase II. The Concept Development Tool is an extension of an existing computer-based training (CBT) system DCS previously developed for training infrared concepts and target recognition skills.

The Phase I findings suggest that the primary purpose of the NDTA is to train perceptual and decision skills rather than vehicle control skills. In addition, the results suggest that the NDTA should train drivers to recognize the effects of environmental variables and illumination on I^2 imagery and should train proper focusing and adjustment skills.

DCS analyzed data from the U.S. Army Safety Center between 1986 - 1996 on ground vehicle accidents involving a night vision device. The purpose of this analysis was to identify driving tasks, obstacles and hazards, and conditions that were most likely to result in accidents and which should have the highest priority for inclusion in the NDTA. This analysis indicated that over two-thirds of the accidents were attributable to three categories of terrain and roadway hazards/obstacles: drop-offs greater than three feet (34%), ditches of three feet or less (23%) and rear-end collisions with another vehicle (11%). The most commonly occurring environmental conditions cited as contributing factors were dust (24%), blooming from light source (9%), and smoke (8%).

The inability to detect a hazard or obstacle resulted in 43% of the accidents. Nearly two-thirds (63%) of the accidents involving drop-offs greater than three feet were due to detection errors. The results of the analysis of ground vehicle accidents and interviews with unit training personnel indicate that the most critical skills to be trained in the NDTA were:

- determining the depth of depression and ditches,
- judging vehicle distance and closure rates,
- detecting and estimating the distance to obstacles,
- detecting and estimating the distance to roadway edges, and
- recovering from exposure to light.

The results of this review indicate that the NDTA will have, at a minimum, the following top-level functions. Specifically, the NDTA will:

- provide the driver with tutorials on I^2 systems and concepts;
- demonstrate NVG resolution and field of view limitations;
- provide a means to train drivers to understand the impact of not properly preparing, adjusting, and focusing the NVGs;
- show drivers what various hazards may look like so that they will have some degree of experience in detecting the hazards that have caused accidents;
- provide a means to train drivers to anticipate the effect of dust, fog, low light level, and other environmental conditions on the performance of NVGs;
- provide a variety of scenes and scenarios in an interactive setting so that the trainee is not a passive observer as when viewing video tapes or using non-interactive educational software;
- provide the opportunity for training depth and distance judgment skills, and obstacle detection and assessment skills;

- provide the driver with the opportunity to observe consequences of various decisions about negotiating obstacles;
- provide the driver with the opportunity to experience the effects of speed on obstacle detection and avoidance;
- provide the driver with the opportunity to observe the effects of improper scanning;
- allow measurement of the driver's performance and provide feedback; and
- be low cost so that it is a viable means of conducting training at the unit level where time and money is at a premium.

An examination of training documents, discussions with NVG and night driving SMEs, and analysis of the ground vehicle accident data base, resulted in the development of twelve general training topics for the NDTA and an expanded list of learning objectives and key concepts was developed. A review of current training technologies identified several training device/simulation concepts and training delivery platforms that are candidates for providing night driver training. The concepts were evaluated according to their judged effectiveness for training each of the twelve training topics.

It was determined that a game station (e.g. PlayStation™) implementation can provide training capabilities limited to static and motion video, whereas a high-end personal computer (PC) implementation can provide these training capabilities with the introduction of an artificial environment. A workstation (e.g. Silicon Graphics® Incorporated) is required to provide training capabilities with a real-time artificial environment.

Conclusions

The Phase I results support the need for and the technical feasibility of a Night Driving Training Aid. Furthermore, the findings suggest that the instructional and training technologies are sufficiently advanced for NDTA development. The training delivery platform approaches discussed previously are technically adequate for the associated range of training topics indicated. The results of Phase I indicate that many NVG-aided driving perceptual as well as decision-making skills can be trained using a multimedia high-end PC as the training delivery platform. The results also indicate that training capabilities could be extended if the training delivery platform were upgraded to a workstation-level computer.

The products of Phase I were (1) a final report documenting the project objectives, technical approach, findings, and recommendations, and (2) a NDTA Concept Development Tool containing four sample lessons on CD-ROM. In May 1997, the project results were briefed to representatives from the DBBL, the Army Research Institute, the Directorate of Training Developments at Fort Benning, and Project Manager, Night Vision/Reconnaissance, Surveillance and Target Acquisition (PM NV/RSTA) organization.

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AR	Army Regulation
.AVI	Audio Visual Interactive
APC	Armed Personnel Carrier
BFV	Bradley Fighting Vehicle
CBT	Computer-based Training
CDi	Compact Disk Interactive
CPU	Central Processing Unit
CRANEIPM	CRANE Intensifier Performance Model
CRT	Cathode Ray Tube
CUCV	Commercial Utility Cargo Vehicle
DBBL	Dismounted Battlespace Battle Lab
DCS	DCS Corporation
DVE	Driver's Vision Enhancer
FM	Field Manual
FLIR	Forward Looking Infrared
FOV	Field of View
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HMD	Head-mounted Display
HW	Hardware
I^2	Image Intensifier
IR	Infrared
LCD	Liquid Crystal Display
LAV	Light Armored Vehicle
NCO	Noncommissioned Officer
NDTA	Night Driving Training Aid
NAWC-TSD	Naval Air Warfare Center-Training Systems Division
NSWC	Naval Sea Warfare Center
NVD	Night Vision Device
NVG	Night Vision Goggles
PC	Personal Computer
PLS	Palatized Load System
PM NV/RSTA	Project Manager Night Vision/Reconnaissance, Surveillance and Target Acquistion
PMCS	Preventive Maintenance Checks and Services
PS	PlayStation™
RGB	Red, Green, Blue
SBIR	Small Business Innovation Research
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SGI	Silicon Graphics® Incorporated
STRICOM	U.S. Army Simulation, Training and Instrumentation Command
SW	Software
TC	Training Circular

TRADOC	U.S. Army Training and Doctrine Command
USAIS	U.S. Army Infantry School
USASC	U.S. Army Safety Center
USAF	U.S. Air Force
USAR	U.S. Army Reserve
USATS	U.S. Army Transportation School
VCR	Videocassette Recorder
VRML	Virtual Reality Modeling Language
VE	Virtual Environment
WWW	World Wide Web

Development Of A Night Driving Training Aid Concept

SECTION 1: INTRODUCTION

1.1 Purpose of the Report

This report documents the results of a Phase I Small Business Innovation Research (SBIR) project to evaluate the feasibility of developing a Night Driving Training Aid (NDTA) for training Army drivers to drive with Image Intensification (I^2) devices at night. The project was conducted in response to solicitation A96-176a issued by the U.S. Army Simulation, Training and Instrumentation Command (STRICOM) to develop an innovative low cost, effective, and interactive night driving training device/simulator concept. The project was sponsored by the Dismounted Battlespace Battle Laboratory (DBBL). Discussions with the project sponsor during the project indicated that the desired product should be a training aid rather than a simulator to be consistent with the needs and expectations of the end user. Accordingly, we refer to the Night Driving Training Aid (NDTA) throughout the remainder of this report.

1.2. Organization of the Report

The report is organized into four sections. The first section provides a statement of the problem leading to the Phase I SBIR. The second section provides the reader with an overview of current Army night vision goggle (NVG) driver training. The third section describes the six research tasks that were accomplished to meet the project objectives and includes the research approach and findings. The fourth and final section summarizes our findings and provides recommendations for the development of a NDTA in Phase II.

1.3. Statement of the Problem

The insertion of technology into the military has seen many turning points in its history. However, one of the most significant factors in the recent evolution of how the Army performs its function has been the ability to continue operations during the night and under conditions of low visibility. Night vision devices (NVDs), including I^2 and infrared (IR) devices, have given the U.S. Army a significant advantage over potential adversaries whose operations at night are degraded. These night vision devices are being used by dismounted soldiers, aviators, and drivers of combat and tactical wheeled vehicles. The use of NVDs has enhanced operations at night by allowing increased mobility and potentially safer operations. With this increased capability in the night environment has come an increased exposure to the hazards of that environment and the risks that the command structure must manage and balance with mission requirements.

To aid in the risk assessment and risk management process, the U.S. Army Safety Center published a special night-vision issue of "Countermeasure" in February 1996. This document addressed several of the major issues that have an impact on managing the

risks associated with the use of NVDs including a "Leader Tip" that "NVD proficiency is a 'use it or lose it' skill." Army leaders were advised not to assume that soldiers are proficient unless they have trained with NVDs recently. The document made several important points regarding training and proficiency. One of the methods used to convey key points in the document was to provide samples of accident scenarios including that of three Bradley Fighting Vehicles (BFV) that inadvertently nosed over a 15 foot embankment with catastrophic results. The results of recent surveys evaluating the use of NVDs in ground vehicles (Piccione and Ferrett, 1996), accident data, and experiments by the DBBL (Dismounted Battlespace Battle Lab, 1995), suggest that the ability to judge the depth of depressions and the perception of distance and closure rates to other vehicles in a convoy are major problems for drivers. In addition, drivers often misjudge the distance to the edge of the roadway, misjudge the width of the shoulder, or make other perceptual errors.

1.4. Night Driving Training Programs

A review of the NVG driver training requirements contained in AR 600-55, *The Army Driver and Operator Standardization Program (Selection, Training, Testing, and Licensing*) as well as manuals and training circulars such as TC 21-305-2 *Training Program For Night Vision Goggle Driving Operations* and FM 21-*305 Manual for the Wheeled Vehicle Driver* show that while the training curriculum addresses the recognition of ditches and other road conditions, there is little emphasis on the recognition of the hazards that seem to be causing accidents. Drivers are often vigilant, but lack a knowledge of the cues that could help them spot the depressions and properly judge their depth and configuration.

During discussions with subject matter experts (SMEs) from the U.S. Army Safety Center, the U.S. Army Research Institute for the Behavioral and Social Sciences, and the DBBL, a recurring concern is that there was inadequate training on how to properly focus NVGs and how to use the devices to detect possible hazards in the operational environment. The drivers have had most of their experience during day conditions or at night with headlights and do not understand that many of the cues they previously relied on are no longer available. It is difficult for an individual to determine what is missing from the visual environment.

It appears that there is no formal night driving training program at the U.S. Army Infantry School at Fort Benning and little that units can tap when conducting their own training. Only a familiarization course in NVG driving is available for Noncommissioned Officers (NCOs) and no formal course is available for officers or enlisted personnel. In addition, SMEs often cite the observation that recency of experience is positively related to the ability of drivers to properly utilize NVDs.

There is a great deal of variability in unit training programs. TC 21-305-2 outlines a standardized method of safely training licensed wheeled vehicle operators to drive while wearing the AN/PVS-5 or AN/PVS-7 series NVGs. The circular outlines a

22.5 hour block of instruction that requires one instructor for the academic portion and one instructor per student for the practical exercise. Some units may do little or no training. Other units comply with the requirements to varying degrees and some have taken the hazards associated with NVG driving seriously and generated their own training program. The Second Brigade, 82nd Airborne Division, Fort Bragg, has developed a program of instruction that is considered by some to be a model night driving training program.

It is apparent that there is some difficulty in preparing drivers to detect the hazards that result in accidents. The training scenarios keep the student in controlled environments and emphasize vehicle control on the road. For training safety, this is a good procedure. However, this does not prepare students to detect hazards or how to properly react. When Army aviators are trained to fly using NVGs, they engage in a progressive program that involves all normal tasks and maneuvers and ultimately includes simulated failures, simulated emergencies, and recovery from the emergencies including touch-down autorotations while wearing NVGs. There appears to be no analogous training in emergencies and hazard recognition for ground vehicle drivers. For safety reasons, it may not be feasible to require a student to drive toward a precipice and such a hazard may not be available where the unit is located.

Video tapes are currently available to provide instruction on the preparation and use of NVGs. In addition, the DBBL has an ongoing effort to collect video images through I^2 devices. There apparently is neither a computer-based training capability nor a simulation capability for NVD training to augment the training that is currently accomplished using overhead transparencies and platform instruction. What is most interesting is that no references have been found or cited by authoritative sources that specifically address training in the use of the AN/VVS-2 (or other NVD) while driving tracked vehicles.

1.5. Need for a Night Driving Training Capability

A review of technical documentation, accident data, and training programs suggests that there is a genuine need for a night driving training aid that will enhance the state of training of ground vehicle drivers. In general the training aid should be low cost, interactive, and provide drivers with experience detecting and recognizing hazards. The functional requirements for the training aid were identified as part of this project and will be described in a later section of this report.

1.6. Project Objectives

The work reported in this paper was performed as part of an SBIR project. The overall project objective is to develop a low cost, effective training aid/simulator, most likely PC-based, for training drivers of wheeled and tracked vehicles to drive safely and effectively with NVGs. The general objectives of Phase I are to:

- explore concepts and design possibilities,
- develop concepts for each of the relevant design possibilities, and
- assess the feasibility for each concept developed.

SECTION 2: CURRENT ARMY NVG DRIVER TRAINING

The U.S. Army has developed an NVG driver training program that incorporates an academic portion with classroom instruction and a performance-oriented hands-on portion. Guidance and procedures for Army NVG driver training are provided in AR 600-55, *The Army Driver and Operator Standardization Program (Selection, Training, Testing, and Licensing*) as well as manuals and training circulars such as TC 21-305-2 *Training Program For Night Vision Goggle Driving Operations* and FM 21-*305 Manual for the Wheeled Vehicle Driver.* Guidance for using I^2 systems is found in technical manuals such as TM 11-5855-262-10-2 *Operator's Manual for AN/PVS-7B Night Vision Goggles* and TM 11-5855-249-10 *Operator's Manual Driver's Night Vision Viewer.*

AR 600-55, *The Army Driver and Operator Standardization (Selection, Training, Testing, and Licensing)* establishes standards, policies, and procedures for the selection, training, testing, and licensing of operators of Army wheeled and tracked vehicles. Chapter 8 "Night Vision Devices" provides commanders with standardized training, testing, and licensing requirements for use of night vision devices (NVDs) by motor vehicle operators. AR 600-55 stresses that "the ability to drive with night vision devices is a highly perishable skill. Proficiency can be developed and maintained only through continuous hands-on training."

FM-21-305, *Manual for the Wheeled Vehicle Driver*, describes NVG driving techniques and procedures, mission planning, safety factors, training programs, and guidance on unit standard operating procedures (SOPs) for wheeled vehicles, motorcycles, and all-terrain vehicles. TC 21-305-2, *Training Program for Night Vision Goggle Driving Operations* provides NVG lesson plans, training calendar, written exam, eye charts, and paper transparencies.

NVD instructors are required to be NVD qualified and licensed on the vehicles on which training is conducted, and must be designated in writing by the commander as certified NVD instructors. NVD instruction must comply with TC 12-305-2 and the guidelines in Chapter 8 of AR 600-55 for qualification and refresher training. NVD instructors implement the commander's program, conduct qualification and refresher

training, administer road tests, and keep the commander informed on the overall status of the unit's NVD profile.

NVG driver training in the Army consists of qualification training during which basic NVG driving skills are acquired, and refresher training during which an individual's proficiency and skills are brought back to an acceptable level after a period of no NVG driving. Qualification training includes sequential instruction in both academic and night driving tasks. During qualification training, the operator receives instruction in academic subjects and must pass a written exam. The academic subjects include the following core topics to which the unit commander is free to add additional topics:

1) introduction to NVGs,
2) awareness of the NVG's diminished effectiveness in rain, fog, snow, or smoke,
3) awareness of the debilitating effects of any bright light, such as headlights or flares,
4) depth perception, visual acuity, and field of vision,
5) illumination requirements,
6) speed limitations,
7) night vision scanning techniques,
8) emergency procedures while driving with NVGs,
9) driver or assistant driver responsibilities and crew coordination,
10) self-imposed stresses (i.e., smoking, alcohol, or driver or crew fatigue), and
11) care and security of the NVGs.

During NVG driver training, the operator receives hands-on instruction in order to demonstrate proficiency while driving with NVGs. During this instruction, a NVG-equipped instructor is in the vehicle with the student. Driving tasks are performed in a specified sequence under the supervision of a qualified NVD instructor in a series of tasks of increasing difficulty. These tasks are performed in five phases:

- Phase I: The soldier drives the vehicle without the device over a known range during daylight conditions and becomes comfortable with the actual road and terrain.
- Phase II: The soldier drives the vehicle using the headlights without the NVGs over the same range at night.
- Phase III: The soldier performs pre-operation NVG checks, checks for proper wear and fitting, focuses the NVG, performs vehicle preventive maintenance checks and services (PMCS) wearing the NVG, and refocuses the NVG immediately prior to Phase IV.
- Phase IV: The soldier performs the following tasks while wearing the NVG during which he or she is instructed to attend to the distance between the vehicle and familiar objects in the front field-of-view.
    1) successfully drive over the same range,
    2) identify road signs,
    3) detect route markers,

4) identify and negotiate ditches or other rough road conditions,
5) identify the edge of the road,
6) correctly judge the distance to road junctions, and
7) distinguish shadows from other features (i.e., water puddles, holes).

- Phase V: The soldier performs post-operation vehicle PMCS while wearing the NVGs, performs post-operation NVG system checks, and completes an after action report.

Refresher training is conducted for active duty motor vehicle operators who have not participated in an NVG driving mission in the past six months (12 months for U.S. Army Reserve [USAR] and U.S. Army National Guard [ARNG] operators). The minimum requirements for refresher training is to demonstrate proficiency in all qualification training tasks and to successfully complete an NVG driver performance test given by an instructor.

SECTION 3: RESEARCH TASKS

The six research tasks identified to meet the general objectives are listed below. The relationship among the tasks is shown in Figure 1. The approach adopted to perform each task and the findings from that task are described in the following subsections.

1) Specify NDTA training objectives and cost/performance constraints
2) Explore simulation concepts and design possibilities
3) Specify night driving tasks and determine training requirements
4) Specify NDTA top level functions and system configuration
5) Develop a partial NDTA to test concept feasibility
6) Develop NDTA functionality requirements

3.1. Specify NDTA Training Objectives and Cost/Performance Constraints

3.1.1. Approach

The purpose of this task was to identify the training or learning objectives for the NDTA and to determine, at least in a relative manner, the cost and performance constraints within which we would be working. Specifically, what are the behaviors, knowledge, or skills that the driver should exhibit after receiving this training, the conditions under which the behavior should be accomplished, and the standards of performance. To accomplish this task we conducted a review of current Army NVG driver training programs. The sources we consulted were Army technical and training manuals, training developers, and unit training personnel.

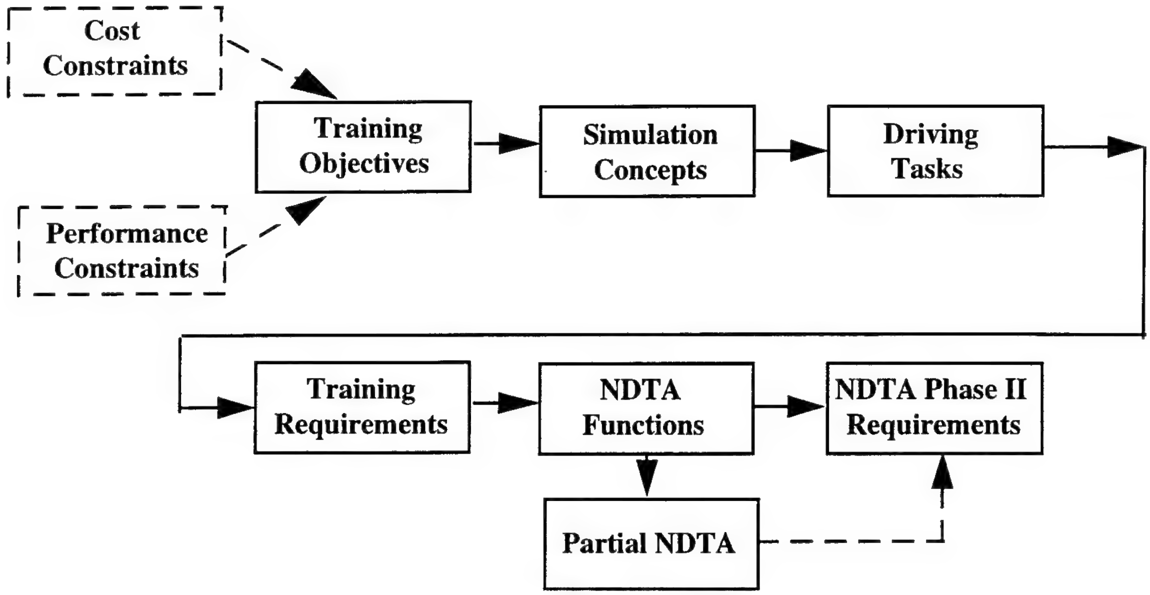


Figure 1. Relationship among Phase I tasks.

3.1.2. Findings

3.1.2.1. Training Objectives

The top-level objective of the NDTA is to provide drivers of Army tracked and tactical wheeled vehicles with the opportunity for acquiring and improving their knowledge of NVG capabilities and limitations and image interpretation skills. The knowledge obtained and the skills developed by using the NDTA should result in a positive transfer of training to in-vehicle NVG driving. The NDTA is not intended to train drivers in vehicle control skills. Drivers will possess these basic skills before being trained on the NDTA.

We also identified five subordinate training objectives. Specifically, at the end of training with the NDTA, the driver should be able to:

1. detect and interpret the image cues in the NVG visual scene that provide information for detecting obstacles,
2. detect and interpret image cues for judging distance and depth,
3. detect and recognize an obstacle in the vehicle path, assess its hazard potential, and identify the appropriate action,
4. recognize the effects of environmental conditions on NVG performance, and
5. recognize when the light level and environmental conditions are insufficient to permit safe NVG operations.

In addition, the NDTA should be designed to complement and integrate with the existing NVG driver training programs described in the previous section.

3.1.2.2. Cost/Performance Constraints

Early on in the project we conferred with the DBBL, the project sponsor, to obtain their recommendations for reasonable cost and performance constraints. We considered this information to be essential for determining the scope of our investigation. During our discussions, the project sponsor did not commit to an upper cost limit but recommended that DCS provide a range of simulation/training aid options with accompanying estimates of cost as part of the investigation. Likewise, the expected performance benefits from the different options would be estimated.

3.2. Explore Simulation Concepts and Design Possibilities

3.2.1. Approach

The purpose of this task was to examine and evaluate simulation and training aid concepts for training NVG driving skills and to determine their implications for the design of the NDTA. We reviewed the technical literature on driver simulation and training to identify candidate simulation and training concepts that might be suitable for or adapted to the NDTA. This included literature on NVG aviation training programs developed by the U.S. Army, U.S. Navy, U.S. Marine Corps, and the U.S. Air Force and literature on NVG driver training programs developed by the U.S. Army.

3.2.2. Findings

3.2.2.1. Computer-based Training Systems

Several computer-based training (CBT) systems have been developed for NVD training. The majority of these CBT training systems obtain static or dynamic (partial or full motion) video imagery from a source such as videodisk or videocassette recorder (VCR) and insert the image into the appropriate portion of a CBT lesson. Some training systems incorporate digitized video such as .AVI files. This approach requires a corresponding frame or series of video frames for every example of NVD image phenomena illustrated. Another approach, used by DCS Corporation in their forward looking infrared (FLIR) CBTs, combines techniques of simulation and real imagery by using algorithms to alter individual pixels in a digitized picture to represent the transformed image.

There is an ongoing program of research on developing instructional multimedia systems for NVG training at the Naval Postgraduate School in Monterey, California (Bryant and Day, 1994; Ciavelli, Sengupta, and Baer, 1994; Epperson, 1995). As part of a multi-year effort funded by the Naval Air Systems Command, this group is building a hypermedia instructional system that will enable aviators to learn critical perceptual skills required for the effective use of NVGs. The system will provide self-paced instruction,

along with practice and rehearsal sessions, and will evaluate students on their progress and provide feedback.

The U.S. Air Force (USAF) has established the Armstrong Laboratory Training Research Division, Night Vision Program Office at Williams Air Force Base, Arizona, to meet the operational training requirements of both existing and future NVD systems. This program has developed a prototype course for NVD ground training which utilizes a CBT approach for part of the training and which is in use or is undergoing implementation by all USAF major commands (Berkley, 1992). Individual modules include:

- Visual Physiology and Spatial Orientation,
- Fatigue and Circadian Rhythm,
- The Night Environment and NVD Theory,
- NVG Adjustment and Preflight Assessment Procedures,
- Cockpit Procedures and Lighting,
- Lessons Learned, and
- Hazards and Emergency Procedures.

The Air Force efforts in video media development include the production of individual video tapes that address NVG adjustment procedures and a broad spectrum of NVG effects, limitations, and illusions, and an interactive videodisk to be assessed as a self-paced, stand-alone audiovisual instructional aid. Work is also underway at Armstrong Labs to integrate NVG-video into existing interactive CBT software.

3.2.2.2. Simulation vs. Stimulation

In addition to using pre-recorded static image or dynamic video, there are two basic approaches to providing image interpretation training opportunities for NVGs in a setting prior to actually wearing the NVGs in the operational environment: simulation and stimulation. Each has its advantages and disadvantages for NVG training applications.

In the <u>simulation</u> approach, a video image is generated from an image generator using a visual data base and displayed on a video display such as a cathode ray tube (CRT) or liquid crystal display (LCD). The image may also be presented on a miniature CRT or LCD that is part of a head-mounted display (HMD). If the image is to follow the observer's line of sight, a head-tracker needs to be included as part of the total system. Visual effects, including NVG-specific effects such as blooming, scintillation, and washout, are modeled in the data base.

A method for providing simulation of night vision imagery in an interactive flight simulator environment is described in Hebb (1991). Hebb summarizes the results of developmental efforts at the Naval Air Warfare Center-Training Systems Division (NAWC-TSD) in NVG training. A helmet display NVG concept was investigated which represents an alternative to flight simulators of the Weapons Tactics Trainer type and

could provide significant enhancements to classroom and on-the-job-training. The desired outcome of this effort is a part task trainer that could be developed using the helmet-mounted NVG concept that would bridge the gap between classroom and flight.

Hebb recommended that further work is needed in developing the NVG helmet display concept, including image generator database work, simulated NVG goggle displays, improved head tracker sampling rates, and improved head motion compensation. At the time the report was published, several SBIRs were in progress to provide simulated NVG goggles, design and deliver improved head trackers, and design an image generator specifically for providing imagery consistent with NVG characteristics.

The stimulation approach involves providing visual imagery that is visually and spectrally correct to stimulate the actual NVGs worn by an observer. Ideally, the resultant experience should be similar to or nearly identical to viewing the real world scene with NVGs under realistic night illumination conditions.

We contacted other researchers at the NAWC-TSD to discuss ongoing work on NVG simulation and stimulation. They indicated that the approach preferred at NAWC-TSD is to provide visual imagery that is correct or nearly correct radiometrically (near IR) and photometrically (visible light) that is very similar to the imagery one observes while wearing NVGs. Techniques for accomplishing this include projecting a scene from film through a near-infrared projector that is observed by individuals wearing NVGs. Another technique is to use a 3-gun red, green, and blue (RGB) CRT and to turn off the blue and green guns and decrease the output of the red gun to a extremely low level. We also contacted researchers at the U.S. Air Force Armstrong Laboratory, Williams Air Force Base, Arizona to discuss their work on NVG training. The approach preferred by this lab is to use image generation techniques and insertion with head tracking and an HMD.

3.2.2.3. Head-mounted Display/Virtual Environment

NVG training using HMDs can be used with either a simulation or stimulation approach. In addition, an HMD may or may not involve a head tracker. However, providing NVG video imagery through actual or surrogate NVGs that is not consistent with head movement, or that lags behind head movement by an appreciable amount, is liable to produce spatial disorientation and nausea.

Virtual environments (VEs) have become very popular in recent years as applications for training. VEs are characterized as immersive and interactive environments in which the learner interacts with the environment in three dimensions. However, VEs have a number of drawbacks that make them less attractive for use in NVG-aided driver training. They have high computational costs, require extensive developmental efforts, typically require high-end hardware and software, and are prone to cause simulator sickness (e.g., spatial disorientation and nausea). The results of our

investigation suggest that a fully immersive VE may not be appropriate as a candidate for a night driving training concept.

3.2.2.4. Driving Simulators

We also examined several full scale driving simulators. Full scale driving simulators are complex and expensive devices, with costs typically in the hundreds of thousands or millions of dollars (e.g., Hein, 1993). Driving simulators incorporate extensive visual data bases, image generators, and computer control and are designed to train basic and advanced driving skills, such as vehicle control and reaction to external events in the driving environment. We concluded that driving simulators in this class were well beyond what was desired or necessary to meet the training objectives or affordable in the numbers desired by the Army.

3.2.2.5. Training Device/Simulation Concepts

Table 1 presents a summary of training device/simulation concepts that we evaluated as candidate concepts for the NDTA. The concepts are arranged in increasing order of capability, complexity, and cost. Each concept is described in detail in the paragraphs that follow.

Table 1. Training Device/Simulation Concepts.

Number	Description
1	Static images with text, linear, noninteractive
1A	Static images with text, linear, noninteractive, canned video
2	Static images with text nonlinear, noninteractive
2A	Static images with text, nonlinear, noninteractive, canned video
3	Static images with text, nonlinear, interactive
3A	Static images with text, nonlinear, interactive, canned video
4	Static images with text, nonlinear, interactive, canned and alternate path video
5	Artificial environment (non-real time)
6	Artificial environment (real time)
6A	Artificial environment (real time) with head tracker

Concept 1 uses static or still images (with no motion) and presents text on the screen. A linear presentation format means that material is presented in a predefined order. It is noninteractive in that the program will not change its presentation based on an input by the learner. This concept is essentially an "electronic page turner" and does not take advantage of any CBT-unique capabilities. Concept 1A has all the capabilities of Concept 1 with the addition of "canned video". Canned video refers to prerecorded dynamic video from a video file or from an external video source, such as a video cassette or a videodisk. The same video always follows a specific response by the learner.

Concept 2 has all the capabilities of the Concept 1 but is nonlinear. By nonlinear is meant that the presentation is not locked into a set sequence of material, but the student can move around in a random fashion. Concept 2A has all the capabilities of Category 2 with the addition of canned video (see Concept 1A).

Concept 3 differs from Concept 2 in that the opportunity for interactivitity is introduced. The concept can be interactive based on simple point-and-click selections by the learner or can be interactive based on learner performance, such as the type of learner response or speed or accuracy of responding. Concept 3A has all the capabilities of Concept 3 with the addition of canned video (see Concept 1A).

Concept 4 has all the capabilities of Concept 3A with the addition of "alternate path video." That is, the learner can be presented with different canned video segments depending on his or her response to different choices. For example, if the learner approaches a ditch, he or she may choose to proceed into the ditch or go around the ditch. The program will show a video segment that is contingent on the learner's response and provide feedback about the appropriateness of the response.

Concept 5 uses an artificial or simulated visual environment. That is, the visual environment is not represented by prerecorded video but is generated mathematically from a visual image data base. This category includes artificial environments that have limited image quality, resolution, and speed due to the limitations on the computational and memory resources.

Concept 6 differs from Concept 5 in that the quality and resolution of the imagery as well as the speed of presentation is at or near real time due to the capabilities of the computational and memory resources. Concept 6A is the same as Concept 6 with the addition of a head tracker for measuring the position and line of sight of the learner's head. A head tracker will allow the user to change the video or simulated imagery presentation on the display based on the learner's head position and line of sight, as would be the case if a driver were scanning with the NVGs.

It should be noted that it is possible to substitute an HMD as a display medium in any of the concepts, and would be most appropriate for Concept 6A. Addition of an HMD would increase the complexity and cost of the concept significantly. However, using an HMD may be the only way to approximate the experience of changes in the NVG image that would result from head movement and scanning.

3.3. Specify Night Driving Tasks and Determine Training Requirements

3.3.1. Approach

Once the overall training objectives and subordinate objectives of the NDTA were specified in Task 1, we developed a list of night driving tasks. Our goal was to identify those tasks that should be trained in an NDTA. We reviewed several Army

technical and training documents that provided guidance for NVG driver training. The findings from this review are summarized in the following section. We also contacted representatives from the U.S. Army Transportation School, Fort Eustis, the U.S. Armor School, Fort Knox, and the 2nd Brigade, 82nd Airborne Division. In addition, we conducted an analysis of data on ground vehicle accidents from the U.S. Army Safety Center from the period 1986 - 1996. The accidents involved the use of one or more NVDs.

3.3.2. Findings

3.3.2.1. Driving Tasks

We found that no single source provided a comprehensive listing of NVG driving tasks. The task list shown in Table 2 was compiled from document reviews and SME interviews. Generally, the tasks can be classified as vehicle guidance/control tasks and object (obstacle) detection tasks.

3.3.2.2. Analysis of Ground Vehicle Accidents

We analyzed data from the U.S. Army Safety Center on ground vehicle accidents involving a night vision device during the period 1986 - 1996. The purpose of this analysis was to identify driving tasks, obstacles, hazards, and conditions that were most likely to result in accidents and which should have the highest priority for inclusion in the NDTA. We identified 160 accidents that were relevant to the project. Detailed data on the accidents we evaluated can be found in Appendix A. Summaries of the primary findings are described in the following paragraphs.

The analysis indicated that over two-thirds of the accidents were attributable to three categories of terrain and roadway hazards/obstacles: drop-offs greater than three feet (34%), ditches of three feet or less (23%) and rear collisions with another vehicle (11%). Of the types of vehicles involved, over one third (34%) of the accidents involved the High Mobility Multipurpose Wheeled Vehicle (HMMWV), 18% involved the M1 Abrams Tank, and 14% involved the M2/M3 Bradley Fighting Vehicle. Data were not available on relative exposure rates. The most commonly occurring environmental conditions cited as contributing factors were dust (24%), blooming from light source (9%), and smoke (8%). Table 3 shows the hazards which are the major categories found in the accident summary data and shows the number of and percentage of accidents in each category.

Table 2. NVG Driving Tasks.

Task	Task Type
Use a ground guide while backing vehicle	Control/Guidance
Successfully drive over designated route	Control/Guidance
Maintain steady speed within speed limit	Control/Guidance
Maintain vehicle position on road during turn	Control/Guidance
Maintain vehicle position on road on curves	Control/Guidance
Use proper NVG scanning technique	Object Detection
Identify terrain features	Object Detection
Identify potential hazards	Object Detection
Detect road signs	Object Detection
Read road signs	Object Detection
Detect route markers	Object Detection
Identify and avoid obstacles	Object Detection
Identify and negotiate ditches	Object Detection
Identify and negotiate rough road conditions	Object Detection
Identify the edge of the road	Object Detection
Maintain proper vehicle position with respect to the edge of the road	Control/Guidance
Maintain proper distance between vehicles	Control/Guidance
Correctly judge the distance to road junctions	Control/Guidance
Recognize shadows	Object Detection
Distinguish shadows from other features (i.e., water puddles, holes)	Object Detection

We inspected the accident data to determine the effect of environmental conditions on the accident scenario. Low illumination was often cited, but insufficient information existed to directly determine the illumination level. Of the 160 accidents reviewed, several environmental conditions were cited as contributing factors. The most commonly occurring conditions are listed in Table 4 along with the number and percentage of accident reports citing that condition. More than one condition may have been cited for each accident. As described previously, dust was the major contributing environmental condition.

The number and percentage of accidents by vehicle type is shown in Table 5. Table 6 presents a breakdown of the vehicle types by type of obstacle for the vehicles accounting for at least 5 accidents. The data in Table 6 indicate the highest percentage of accidents occurred involved the HMMWV driving into a drop-off greater than three feet or a ditch less than three feet. The number and percentage of accidents by time of day is shown in Table 7. Over a quarter of the accidents (27%) occurred between 2000 - 2159 hours.

Table 3. Number And Percentage Of Accidents By Driving Hazards Category.

Hazard Category	Number of Accidents		Percentage of Accidents	
Terrain and roadway hazards				
Drop-off - greater than 3'				
To front of vehicle	23		15%	
To right side of vehicle	5		3%	
To left side of vehicle	5		3%	
Unknown location	21		13%	
Total		54		34%
Ditches - 3' or less				
To front of vehicle	1		1%	
To right side of vehicle	13		8%	
To left side of vehicle	7		5%	
Unknown location	15		9%	
Total		36		23%
Vehicle (rear aspect)	17		11%	
Steep grade	8		5%	
Personnel	8		5%	
Rise in terrain to the front (e.g., berm)	6		4%	
Large rock in vehicle path	6		4%	

Note: Categories with less than 5 accidents are not reported.

Table 4. Number And Percentage Of Accidents By Environmental Conditions.

Environmental Condition	Number of Accidents	Percentage of Accidents
Dust	39	24%
Blooming from light source	14	9%
Smoke	13	8%
Fog	10	6%
Rain	10	6%

Note: Not all accident records contained reports of environmental conditions.

Table 5. Number And Percentage Of Accidents By Vehicle Type.

Vehicle Type	Number of Accidents	Percentage of Accidents
HMMWV	55	34%
M1	28	18%
M2/M3	17	10%
HEMTT	12	7%
M113 (includes variants)	12	7%
Truck - 5 Ton Cargo	8	6%
Truck - 5 Ton Tractor	5	3%
Truck - 2.5 Ton Cargo	4	3%
Truck - unknown type	3	2%
M60	3	2%
Motorcycles	3	2%
CUCV	2	1%
M109	2	1%
M551	2	1%
LAV	1	1%
Unknown	3	2%

Note: N = 160

We further broke down the hazard/obstacle data using an error classification scheme proposed by Wiegmann and Shappell (1997). This scheme classifies driver errors by their occurrance in a series of information processing events (i.e., detection, assessment). Table 8 presents a summary of the error categories and the percentage of accidents within each category. The data in Table 8 clearly indicate that the inability to detect a hazard or obstacle resulted in the highest percentage of accidents (43%). The second highest percentage of accidents (19%) occurred when drivers detected an obstacle but misjudged its size, depth, or location. This suggests that drivers using NVGs may lack the required image interpretation skills to use the NVGs safely and effectively. Table 9 presents a breakdown of the driver error categories by obstacle/hazard category. The data in Table 9 indicate that nearly two-thirds (63%) of the accidents involving drop-offs greater than three feet were due to detection errors.

Table 6. Number of Accidents Within Categories of Vehicle Types and Obstacles

	HMMWV	M1	M2/M3	HEMTT	M113	Truck 5 Ton Crg	Truck 5 Ton Trct	TOTAL
Drop-off >3'	23	13	7	1	5			49
Ditch <3'	15	4		3	4	3	3	32
Vehicle Rear	1	4	5	3		2	1	16
Steep Grade	2	2	1	2		2		9
Personnel	4		1	3	1			9
Rock	4						1	5
Rise in Terrain		1	1					2
Maneuver						1		1
Soil Collapsed	1	1						2
Low Obstacle	1	1						2
Vehicle Front		1			1			2
Hole	1		1					2
Edge of Bridge	1				1			2
Rough Terrain	1		1					2
Sand	1							1
Water		1						1
Total	55	28	17	12	12	8	5	137

Note: Vehicles with fewer than five accidents are not represented.

Table 7. Number and Percentage of Accidents by Time of Day.

Time of Day	Number of Accidents	Percentage of Accidents
1800 - 1959 hrs	14	8%
2000 - 2159 hrs	43	27%
2200 - 2359 hrs	29	18%
2400 - 0159 hrs	27	17%
0200 - 0359 hrs	28	18%
0400 - 0559 hrs	18	11%
0600 - 0645 hrs	1	1%

Note: N = 160

Table 8. Percentage Of Accidents By Driver Error Category.

Code	Driver Error Category Description	Percentage of Accidents
NODET	Driver did not detect the obstacle prior to the impact, or detected the obstacle immediately prior to impact.	43%
AWMIS	Driver was aware of the presence of the obstacle, but misjudged the size, depth, or location of the obstacle.	19%
DECIS	Driver was aware of the obstacle and correctly judged the obstacle characteristics, but made an improper decision on how to proceed.	6%
EXECU	Driver made a proper decision regarding the obstacle, but improperly executed the action.	15%
SUD	Driver properly executed the action, but had no opportunity to avoid the impact due to sudden events.	1%
INSUF	Insufficient information was contained in the narrative to determine the type of driver error.	16%

Note: N = 160

Table 9. Number of Accidents Within Categories of Driver Errors and Obstacles.

Hazard	NODET	AWMIS	DECIS	EXECU	SUD	INSUF	TOTAL
Drop-off >3'	34	4	2			14	54
Ditch <3'	8	11	1	11	1	4	36
Vehicle Rear	9	1	3	2		2	17
Steep Grade		5		2		1	8
Personnel	7			1			8
Rock	3	1		2			6
Rise in Terrain			1	1		4	6
Maneuver		1		3		1	5
Soil Collapsed		3		1			4
Low Obstacle	2		1				3
Vehicle Front	1	1					2
Hole	1	1					2
Edge of Bridge		1	1				2
Rough Terrain			1			1	2
Sand		1					1
Shallow Dip				1			1
Water	1						1
High Obstacle	1						1
Wire	1						1
Total	68	30	10	24	1	27	160

The end product of this task is a definition of the specific tasks and skills that can be addressed by the NDTA. The tasks reflect a genuine need by the driving community and show a benefit in terms of maintaining a skill level to enhance proficiency and reduce accidents.

3.4. Specify NDTA Top Level Functions and System Configuration

3.4.1. Approach

The purpose of this task was to identify the top-level functions or training topics to be covered in the NDTA and to establish the system configuration. We reviewed the results of the exploration of alternative concepts generated during Task 2 in light of the tasks and training requirements identified in Task 3. We determined a candidate configuration for the NDTA and specified the functions to be incorporated. The specification describes the physical configuration, hardware required for the training station, and a top-level outline of the training topics. We attempted to derive the specifications in sufficient detail such that a cost estimate for hardware and software could be made.

3.4.2. Findings

3.4.2.1. Training Topics

As a result of our examination of training documents, discussions with NVG and driving SMEs, and analysis of the ground vehicle accident data base, we developed a preliminary list of twelve general training topics for the NDTA. The twelve topics and examples of key concepts contained within each topic are shown in Table 10. These topics were then expanded into a lesson outline which is included as Appendix B.

3.4.2.2. Estimates of Training Effectiveness

After we identified the levels of training/simulation concepts and the twelve categories of training topics, we developed subjective ratings of the effectiveness of each concept for each training topic category. The ratings ranged from 0 = "Not Effective" to 3 = "Highly Effective". The ratings of training effectivenss, shown in Table 11, were generated as a starting point for estimating the level of training/simulation concept, shown in Table 1, that will be required for effective training of the various NDTA training topics. For example, to present the lesson on driver errors, concept 3A will be required at a minimum, and the highest level of training effectiveness is expected to occur with concept 6A.

Table 10. Preliminary List of Training Topics for NDTA.

Number	Name	Examples of Key Concepts
1	Introduction	General capabilities and limitations
2	Types of I^2 Systems	NVGs, AN/PVS-7B, AN/PVS-5, AN/VVS-2
3	I^2 Concepts	How I^2 systems work, effects on I^2 systems
4	I^2 Hardware	Lens system, fiber optics, eye piece
5	I^2 Working Conditions	Environments, illumination
6	Vehicle Conditions	Internal and external lights
7	I^2 Driving Specifics	Obstacle detection and scanning techniques
8	Preparing for a Mission	NVG equipment check and vehicle check
9	Conducting a Mission	Single vehicle, convoy, crew coordination
10	Driving Hazards	Drop-offs, ditches, depressions, personnel
11	Driving Errors	Detection, judgement, decision-making
12	I^2 Driving Simulation	Simulated conditions and predicaments

Table 11. Matrix of Effectiveness Ratings of Training Topics versus Training Device/Simulation Concepts.

		Training Topic											
	Training/Simulation Concept	Introduction	I^2 Systems	I^2 Concepts	I^2 Hardware	I^2 Working Conditions	Vehicle Conditions	I^2 Driving Specifics	Mission Preparation	Driving Mission	Driving Hazards	Driving Errors	I^2 Driving Simulation
1	Static images with text, linear, noninteractive	1	1	1	1	1	1	1	1	0	0	0	0
1A	Static images with text, linear, noninteractive, canned video	1	1	1	1	1	1	1	1	0	0	0	0
2	Static images with text nonlinear, noninteractive	2	1	1	1	1	1	1	1	0	0	0	0
2A	Static images with text, non-linear, noninteractive, canned video	3	1	1	1	1	1	1	1	0	0	0	0
3	Static images with text, nonlinear, interactive	3	2	2	2	1	1	1	1	1	0	0	0
3A	Static images with text, nonlinear, interactive, canned video	3	2	2	2	2	2	2	2	1	1	1	0
4	Static images with text, non-linear, interactive, canned and alternate path video	3	3	3	3	2	2	2	2	2	2	2	0
5	Artificial Environment (Non-real time)	3	3	3	3	3	3	3	3	3	2	2	1
6	Artificial Environment (Real Time)	3	3	3	3	3	3	3	3	3	3	3	2
6A	Artificial Environment (Real Time) with Head Tracker (HT)	3	3	3	3	3	3	3	3	3	3	3	3

KEY: 0 = Not effective; 1 = Low Effectiveness; 2 = Moderate Effectiveness; 3 = High Effectiveness

3.4.2.3. Hardware/Software Architecture

We explored different software and hardware architectures and investigated various hardware options available for the development of the NDTA. Our primary objective was to generate several alternative architectures for evaluation and to examine

the general layout of the hardware/software. Figure 2 describes the hardware interfaces and software interfaces for various envisioned components of the NDTA. The components in Figure 2 are discussed in detail in the following paragraphs and in Appendix D.

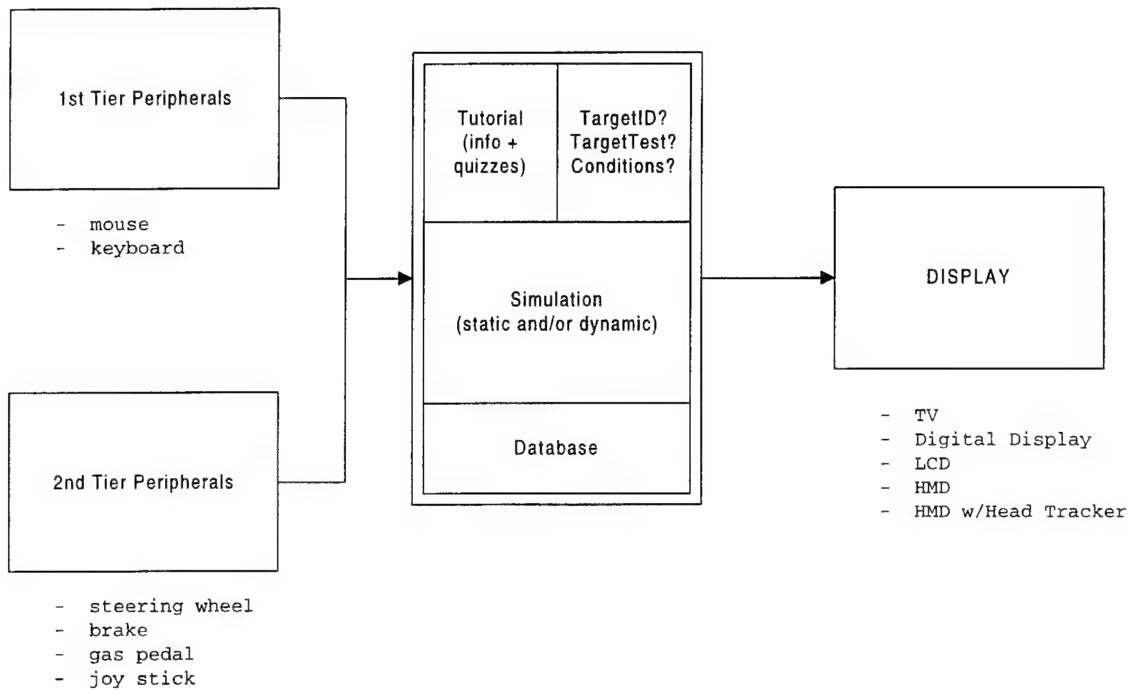


Figure 2. Conceptual hardware/software architecture for the NDTA.

The peripherals can be categorized into two tiers, or levels. First tier peripherals are those which are essential for controlling the selections within the NDTA. Examples of 1st tier peripherals are a mouse and keyboard. Second tier peripherals give more functionality and potential realism to the NDTA. Examples of 2nd tier peripherals are a steering wheel, gas pedal, brake, and joystick which provide the user with a "look and feel" environment to judge their reaction times and to provide at least a partial immersion into the night driving scenario.

The software architecture in the computer (the central box in Figure 2) indicates the types of functionality that might be used to train the individual and to measure and evaluate their performance. The tutorial section would provide information and quizzes to the user to train on various aspects of I^2 equipment theory, the theory of operations, the use of the equipment, the environment to expect, and appropriate and inappropriate techniques for driving with NVDs. There may be a need for target identification in which the user is trained to recognize various targets under different conditions. A target test could be implemented in which the user would be tested on his ability to recognize various targets in a timed manner.

A simulation section would need to be provided with static and possibly dynamic imagery. Static images provide a means of comparing and contrasting various conditions and the effects that they have on the scene being viewed, or comparing NVD imagery with visible imagery. Dynamic images provide a method by which the user can relate moving information to driving under night conditions. This moving information would include such items as moving shapes, contrast changes, etc. The suitability of a dynamic simulation versus a static simulation will depend on the particular skills to be trained. Dynamic simulations, although impressive in appearance, do not necessarily result in positive training except to show the user how to recognize hazards from moving image contrasts. Developing dynamic simulations is costly and must be justified by the expected gain in training benefits. However, both static and dynamic imagery may be appropriate depending on the skills to be trained.

A database section could be added to supply a means of tallying the users response to the quizzes and activities which could be used in later analysis of the NDTA effectiveness. The display may be of several types, each having advantages over the other. The TV/digital display/LCD monitors provide a standard presentation of the night driving imagery. An HMD can be used to provide a more immersive type of environment for training as the specific application warrants.

3.4.2.4. Training Delivery Platforms

We then considered several potential training delivery platforms or implementations. These are listed below and described in detail in the following paragraphs with respect to their advantages, disadvantages, costs, and required developmental effort.

- Sony PlayStation™/Nintendo® (PS)
- Compact Disk Interactive (CDI)
- Personal Computer (PC)
- World Wide Web (WWW)
- Silicon Graphics® Incorporated Workstation (SGI)
- Sun™ Workstation

3.4.2.4.1. PlayStation™/Nintendo®

In this implementation a game-like trainer could be developed which would interface to standard game interfaces. The development effort would be geared to low-cost implementations in which the end hardware device would be useable in the training and recreation rooms. The advantages to developing the NDTA in this manner are the minimized cost of the equipment and the availability of the equipment for use in after hours recreational activities. The processor in the PlayStation™ is a MIPS® type, similar to that in the Silicon Graphics® machine. It offers superior graphics and is designed for producing moving screen images. The tutorial could be easily accommodated with the use of the hand controller, but would need extra devices (beyond the usual PlayStation™

controls) for 2nd tier peripherals. A challenge to developing with this system is to convince the user that the effects are sufficiently real to establish credibility. The media used to transport the NDTA would be a PlayStation™/Nintendo® compatible CD-ROM.

3.4.2.4.2. Compact Disk Interactive (CDi)

In this implementation, the development effort would be geared to a special purpose CDi player which provides standard interactivity and connects to standard televisions for display. There is very little to be found about the CDi technology on the Web or in the commonly available technical literature. More contact is needed with Phillips to determine the costing factors. The media used to transport the NDTA would be a CDi compatible CD-ROM. It should be noted that CDi technology has its own proprietary imaging compression formats and storage techniques. Development for the CDi would require investment in the Phillips developers kit (an unknown cost), manuals on CDi (known to be several hundred dollars), and in a development environment (an unknown cost). CDi was not considered a viable training platform because of the difficulty obtaining descriptive information and the proprietary nature of CDi.

3.4.2.4.3. Personal Computer Without 2nd Tier Peripherals

This implementation would involve using a pentium-level personal computer (PC) as a training delivery system. The advantages of using a PC are that the development tools are known, the development costs are known, the Army has a number of PCs already in place, PCs have uses other than serving as training platforms, and the software can be easily distributed. In this implementation, the development effort would be oriented towards the tutorial/static simulation mode of NDTA. Even though the hardware appears to limit the choices for training using this approach, the training/simulation concept can go up to Concept 4. Most interaction will be by means of point and click self-paced instruction. Video information is presented to the user from .AVI files located on CD-ROM. Dissemination of the trainer and its required files would be strictly by CD-ROM. The disadvantage of this approach lies in the availability of CD-ROM drives on the target machine. The advantage lies in the availability of large number of PCs already in the Army inventory. The trainer may be run off the CD-ROM entirely, giving the added advantage of making any PC with associated CD-ROM a potential NDTA trainer.

3.4.2.4.4. Personal Computer With 2nd Tier Peripherals

This implementation, having all the advantages of the PC without 2nd tier peripherals, has the added advantage of allowing the users to immerse themselves (at least partially) in the simulation. The focus is placed on giving the user more training on driving with I^2 devices in a night time environment. Scenarios may be presented to the user in which he or she may be required to react at a specific time in a scenario. The 2nd tier peripherals communicate the user's reaction to the scenario to the NDTA to make a decision on the user's reaction. This decision would cause the NDTA to branch to

appropriate modules for performance assessment or feedback to reinforce the user's responses. The media to transport the NDTA would be a standard CD-ROM.

3.4.2.4.5. Silicon Graphics®/Sun™Workstation

This implementation offers better and faster graphics than the PC with 2nd tier peripherals discussed above. In addition, the speed and resolution of graphics make this platform a better alternative for training using an HMD and head tracker. This enables the achievement of training/simulation Concept 6A. The advantage to this technique is that it places the user into a total immersion environment. Disadvantages to an immersive environment are that the focus may be more on a virtual reality presentation than on the tutorial aspects of the trainer. In addition, more of the environment may need to be simulated (e.g., the cab of the vehicle, vegetation in fields along the side of the road) than is required in a "single window" mode of operation with the forward field of view. This will increase the complexity of the trainer but will not necessarily result in an increase in training effectiveness. Training on an SGI-level device is not limited to an HMD/head tracker implementation alone. Similar to the PC implementation, the media for transport of the NDTA will be a CD-ROM. Another disadvantage of this implementation is its relatively high cost compared to a PC. This increased cost must be evaluated against the anticipated training benefits.

3.4.2.4.6. World Wide Web

We also evaluated the merits of hosting the NDTA on the World Wide Web (WWW). Although it is possible to host a point-and-click style trainer on the WWW, response time and two-way communication considerations appear to rule this method out as a viable host platform for the NDTA. Response time on the Web is not consistent enough to run video or make alternate path video a workable reality. Two-way interactions requiring the Web site to examine 2nd tier peripheral inputs and/or choices made by the user require specialized programming on both sides of the Web link.

3.5. Develop a Partial NDTA to Test Concept Feasibility

3.5.1. Approach

In addition to evaluating the feasibility of an NDTA concept, which is documented in this report, we developed a partial NDTA that can be used as a Concept Development Tool for evaluating the feasibility of different training concepts. The partial NDTA demonstrates a portion of the content and functionality that would be present in a fully-developed NDTA. DCS has developed, under another SBIR contract, a modular, extensible CBT for training FLIR principles and image recognition skills. This CBT has several features that could be easily adapted for an NDTA Concept Development Tool and was the basis for the tool. These features include:

- decoupling of the code from functionality,
- interactive graphical tutorials and operational concepts,
- operational concepts illustrated with imagery,
- multiple proficiency levels,
- quizzes for testing concept comprehension, and
- hypertext-style glossary lookup.

3.5.2. Findings

The Concept Development Tool we developed allows STRICOM, the DBBL, and the user to evaluate different design and training concepts through rapid prototyping and allows the user to take an iterative design approach and incorporate user feedback. Its design allows quick and easy configuration and tutorial function changes without code changes and allows drop-in simulation routines. The Concept Development Tool contains a minimal set of functions to provide insight into the final functionality needed in a Phase II developmental effort and provides a basis for exploring the ideas generated in the other tasks. The tool contains sample lessons on four topics:

- I^2 tutorial with video,
- night driving hazards,
- using image cues, and
- I^2 simulation.

A detailed description of the purpose, development, and content of the Concept Development Tool and examples of lesson screens are provided in Appendix C. The Concept Development Tool was demonstrated for the project sponsor in May 1997 and delivered to STRICOM at the end of the project.

3.6. Develop NDTA Functionality Requirements

3.6.1. Approach

Based on our findings in Task 1 through Task 4 we developed a set of requirements that will support a fully functional NDTA to be developed in Phase II.

3.6.2. Findings

The results of this review suggest that the NDTA should have, at a minimum, the following top-level functions and characteristics:

- Provide the driver with tutorials on I^2 systems and concepts.
- Demonstrate NVG resolution and field of view limitations.
- Provide a means to train drivers to understand the impact of not properly preparing, adjusting, and focusing the NVGs.

- Show drivers what various hazards may look like so that they will have some degree of experience in detecting the hazards that have caused accidents.
- Provide a means to train drivers to anticipate the effect of dust, fog, low light level, and other environmental conditions on the performance of NVGs.
- Provide a variety of scenes and scenarios in an interactive setting so that the trainee is not a passive observer as when viewing video tapes or using non-interactive educational software.
- Provide the opportunity for training depth and distance judgment skills. and obstacle detection and assessment skills.
- Provide the driver with the opportunity to observe consequences of various decisions about negotiating obstacles.
- Provide the driver with the opportunity to experience the effects of speed on obstacle detection and avoidance.
- Provide the driver with the opportunity to observe the effects of improper scanning.
- Allow measurement of the driver's performance and provide feedback.
- Be low cost.so that it is a viable means of conducting training at the unit level where time and money is at a premium.

SECTION 4: SUMMARY AND RECOMMENDATIONS

This report documents the results of a Phase SBIR project to evaluate the feasibility of developing a Night Driving Training Aid for training Army drivers to drive with I^2 devices at night. During this project we identified training objectives for the NDTA, explored a variety of training/simulation concepts and designs, identified training NDTA tasks and training requirements, developed a partial NDTA Concept Development Tool, and determined the top-level functional requirements for the development of a NDTA in Phase II.

The findings from this study support previous findings that the majority of problems drivers are experiencing when using I^2 devices are problems with visual perception, such as obstacle detection, recognition, and depth and distance judgment. Thus, the findings suggest that the purpose of the NDTA should be to train perceptual (image interpretation) and decision skills, rather than basic vehicle control skills which the drivers should possess prior to using the NDTA. This approach is predicated on the assumption that it is possible to train a driver to make the correct decision about a control action without requiring him or her to make a continuous control action. From an instructional standpoint, we believe that it is beneficial to separate the decision making phase from the response execution phase.

In addition the NDTA should train the driver to recognize the effects of environmental variables and illumination on I^2 imagery and should train proper focusing and adjustment skills. The results of the analysis of ground vehicle accidents and

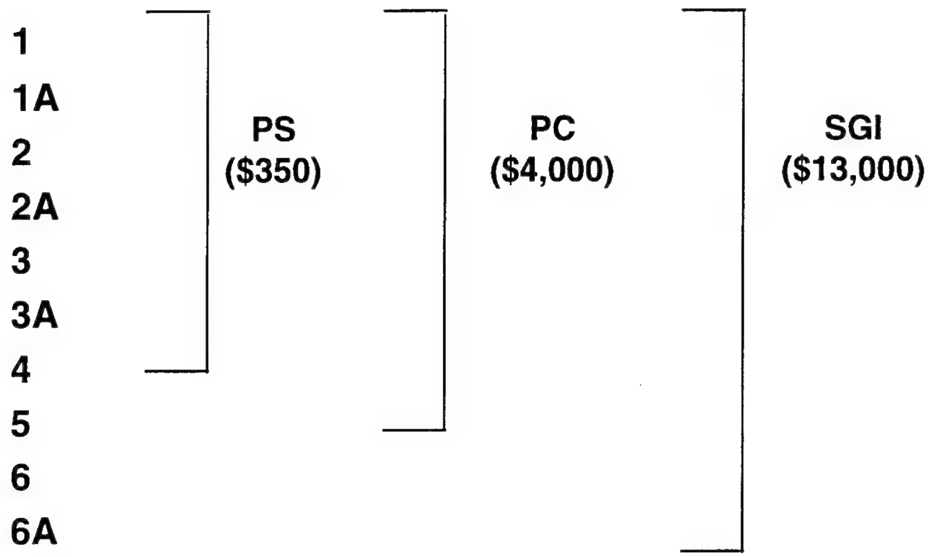
interviews with unit training personnel indicated that essential skills to be trained in the NDTA should include:

- determining the depth of depression and ditches,
- judging vehicle distance and closure rates,
- detecting obstacles,
- estimating the distance to obstacles,
- detecting and estimating the distance to roadway edges, and
- recovering from exposure to light.

The range of training device/simulation concepts, described in Table 12, to which each implementation would apply and a rough estimate of recurring costs is summarized in Figure 3. In each case, the cost estimates are for a basic, entry level system (e.g., an SGI O2™). The costs will be higher for advanced, fully-equipped and militarized systems. Figure 3 shows that a PlayStation™/Nintendo® delivery platform could be used to provide capabilities up to Concept 4. A pentium-level PC implementation would provide these capabilities and would also allow training in a non-real time artificial environment. Lastly, using a SGI implementation would provide the additional capability of Concept 6A, an artificial environment (real time environment).

Table 12. Training Device/Simulation Concepts.

Number	Description
1	Static images with text, linear, noninteractive
1A	Static images with text, linear, noninteractive, canned video
2	Static images with text nonlinear, noninteractive
2A	Static images with text, nonlinear, noninteractive, canned video
3	Static images with text, nonlinear, interactive
3A	Static images with text, nonlinear, interactive, canned video
4	Static images with text, nonlinear, interactive, canned and alternate path video
5	Artificial environment (non-real time)
6	Artificial environment (real time)
6A	Artificial environment (real time) with head tracker



Note: Estimated hardware costs including peripheral devices

Figure 3. Range of capabilities considered for Phase II.

The goal of this effort is to find a single solution for fielding a night driving training capability to the field or to identify a mix of solutions that would be used at various organizational levels. There is a genuine need for a night driving training device capability in the Army. The proposed approach offers two opportunities to STRICOM for satisfying this need. First, STRICOM will have three levels of NDTA capability and cost to evaluate against training requirements. Second, STRICOM and the DBBL will have a tool which will give them the capability to perform training effectiveness experiments. These experiments are essential for assessing the tradeoffs between training device complexity and cost and the level of skill training effectiveness and can provide valuable inputs to decisions on maximizing scarce training resources and funds.

Based on our analyses and discussions with the DBBL, we recommend that STRICOM consider developing three training device/simulation concepts and capabilities for implementation in a Phase II effort: a PlayStation™/Nintendo® (PS); a pentium-level personal computer (PC), and a Silicon Graphics® Incorporated (SGI) workstation.

This recommendation has been briefed to and supported by representatives from the DBBL, the Army Research Institute, and the Directorate of Training Development at Fort Benning, and the Thermal Branch Chief and the Driver's Vision Enhancer Project Leader in the PM NV/RSTA organization.

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TRADEMARK INFORMATION

PlayStation is a trademark of Sony Incorporated. Nintendo is a registered trademark of Nintendo Incorporated. Silicon Graphics and OpenGL are registered trademarks of Silicon Graphics Incorporated. O2 is a trademark of Silicon Graphics Incorporated. Sun is a trademark of Sun Microsystems, Incorporated. MIPS is a registered trademark of MIPS Technologies, Incorporated.

APPENDIX A

GROUND VEHICLE ACCIDENT DATA SUMMARY

DCS analyzed data from the U.S. Army Safety Center on ground vehicle accidents involving a night vision device during the period 1986 - 1996. A total of 160 accidents were analyzed. The purpose of this analysis was to identify driving tasks, obstacles, hazards, and conditions that were most likely to result in accidents and which should have the highest priority for inclusion in the NDTA. A summary of the primary findings is provided in Section 3.3.2.2. This appendix provides detailed data for each accident case. Information that could be used to identify a specific accident, the individuals involved, or their organizational affiliation, has been excluded. Driver error categories used in Appendix A are listed in Table A-1. A glossary of acrononyms and abbreviations used in Appendix A is provided on the following page. Additional information about the accident data base can be obtained by contacting DCS.

Table A-1. Driver Error Categories.

Code	Driver Error Category Description
NODET	Driver did not detect the obstacle prior to the impact, or detected the obstacle immediately prior to impact.
AWMIS	Driver was aware of the presence of the obstacle, but misjudged the size, depth, or location of the obstacle.
DECIS	Driver was aware of the obstacle and correctly judged the obstacle characteristics, but made an improper decision on how to proceed.
EXECU	Driver made a proper decision regarding the obstacle, but improperly executed the action.
SUD	Driver properly executed the action, but had no opportunity to avoid the impact due to sudden events.
INSUF	Insufficient information was contained in the narrative to determine the type of driver error.

For each accident case, information is provided on the following variables:

- Local time
- Environmental conditions
- Type of vehicle
- Type of night vision device
- Type of error (see Table A-1)
- Obstruction
- Type/position of obstacle
- Size of obstacle
- Speed
- Visual problem/Presence of blooming (Yes/No)

Appendix A
Glossary Of Acrononyms And Abbreviations

APC	Armed Personnel Carrier
BFV	Bradley Fighting Vehicle
BR EDGE	Bridge Edge
CUCV	Commercial Utility Cargo Vehicle
DO	Drop-off
HEMITT	Heavy Expanded Mobility Tactical Truck
HMMWV	High Mobility Multipurpose Wheeled Vehicle
OBS	Obstacle
PERS	Personnel
R TERR	Rough Terrain
VEH FR	Vehicle Front

No.	Local Time	Environment				Type of Vehicle	Type of NVD	Type of Error	Obstruction	Type/Position of Obstacle	Size of Obstacle	Speed	Visual Problem	Bloom
		Rain	Fog	Smoke	Dust									
1	2030					APC M106A2	PVS-7A	NODET	DO	Hole on left			Attention on lead vehicle, didn't see hole.	
2	0415					APC M113	NVG	NODET	DO	Wadi in front			Couldn't see ravine without blackout lights.	
2	2345				X	APC M113 A2	PVS-7B	AWMIS	DITCH	Ditch on right			Didn't see ditch paralleling road on right.	
4	2030					APC M113 A2	NVGs	NODET	DO	Tank ditch in front		< 4-5 mph	Didn't see tank ditch.	
5	0500				X	APC M113 A3	PVS-7B	NODET	DITCH	Ditch			Didn't see ditch.	
6	0230					APC M113A2	PVS-5	AWMIS	BR EDGE	Night road edge		10 mph	Misjudged road, 4 red chemlights marked bridge.	
7	2230		X			APC M548	NVD	AWMIS	VEH FR	2.5 ton truck			Couldn't distinguish vehicles.	
8	0250					APC M577	PVS-7	NODET	PERS	Sleeping soldiers in front			Didn't see soldiers.	
9	2130			X	X	APC M577A2	PVS-7	INSUF	DITCH	Right side of road			Degraded visibility due to dust.	
10	0330					APC M901	PVS-7	NODET	DO	Unoccupied defilade pstion			Didn't see empty defilade position.	
11	0045					APC M901	PVS-7	DECIS	DO	Hole in front	6'	0	2 men carefully viewed "ditch" and couldn't judge depth.	
12	0330					BFV M2	PVS-7	NODET	DO	Defilade low in front			Didn't see M113 dug in in front.	
13	1800					BFV M2	NVGs	DECIS	R TERR	Rough terrain		high	Misjudged acceptable speed for terrain.	
14	2100			X	X	BFV M2	NVDs	NODET	VEH REAR	Stopped BFV in front		15 mph	Didn't see BFV.	
15	0300	X	X			BFV M2A1	Yes	NODET	DO	Forward drop off	4 ft		Didn't see dropoff in poor weather w/ NVGs & flares.	
16	0002					BFV M2A1	VVS2	NODET	DO	Wadi in front	4-5' W, 3.5' D	3-6 mph	Didn't see wadi.	
17	0515			X	X	BFV M2A1	VVS-2	INSUF	VEH REAR	BFV M2A1		12 mph	Couldn't see well.	
18	0230	X				BFV M2A1	VVS-2	NODET	VEH REAR	BFV to right			Blinded by own service lights, couldn't drive safely.	Yes
19	0130					BFV M2A2	PVS-7A	NODET	DO	Unoccupied defilade pstion		"very slow"	Didn't see empty defilade position.	
20	2145					BFV M2A2	VVS-2	EXECU	PERS	Ground guide		1-2 mph	Didn't perceive danger of driving slow close to guide.	
21	0530					BFV M2A2	VVS-2	INSUF	RISE	Slope			Misjudged slope.	
22	0100					BFV M2A2	VVS-2	AWMIS	STEEP	Rut front left, steep grade			Misjudged terrain.	
23	2015					BFV M2A2	VVS-2	NODET	VEH REAR	BFV M2A2		5-10 mph	Blinded by lights.	Yes
24	2130					BFV M3	NVGs	NODET	DO	Tank trap in front	10' W, 5-7' D		Didn't see trap, blind spot in front.	
25	0315					BFV M3	PVS-7B	AWMIS	VEH REAR	BFV			Couldn't see well enough to pass.	
26	2100				X	BFV M3A1	VVS-2	AWMIS	DO	Wadi in front	15 ft. D	<5 mph	Couldn't judge depth or steepness of wadi edge.	
27	0346					BFV M3A2	PVS-7B	INSUF	DO	12' cut at entrance to trail	12'		Misjudged terrain.	
28	1800					BFV M3A2	NVGs	AWMIS	HOLE	Hole			Didn't see hole in time.	
29	1830				X	Carrier M1059	PVS-7B	NODET	DITCH	Drainage ditch on right			Didn't see ditch.	Yes
30	0300					CUCV M1009	PVS-5	INSUF	DO	Embankment (cliff)	25'		Misjudged terrain.	
31	1940				X	CUCV M1010	NVGs	AWMIS	STEEP	Trail edge on right			Couldn't see road well.	
32	2100					HEMTT M977	PVS-7	INSUF	RISE	Crest of a hill			Misjudged severity of hills.	
33	2030				X	HEMTT M977	PVS-7	DECIS	VEH REAR	Vehicle in front			Didn't see vehicle in time to stop.	
34	0255			X	X	HEMTT M977	NVGs	INSUF	VEH REAR	HEMTT M977 in front		15-20 mph	Vision restricted by dust, didn't see truck in front.	
35	2100					HEMTT M978	PVS-7B	INSUF	DITCH	Ditch to left	3' D	<5 mph	Couldn't see well enough to drive.	
36	0155					HEMTT M978	PVS-7B	AWMIS	DITCH	Wadi on left			Miscalculated turn.	
37	0045					HEMTT M978	PVS-7	AWMIS	DO	Ditch at angle	8' W, 3-4' D		Misjudged depth of ditch.	
38	2000		X			HEMTT M978	PVS-7B	AWMIS	MANEUVER	Trail side			Couldn't see road well.	
39	2100				X	HEMTT M978	PVS-7	EXECU	MANEUVER	Wrong trail			Got lost.	
40	0200				X	HEMTT M978	PVS-7	EXECU	MANEUVER	Shoulder			Lost track of road, temp blinded by dust.	
41	2100	X				HEMTT M978	PVS-7	INSUF	RISE	Berm			Misjudged terrain.	
42	0200					HEMTT M985	PVS-7B	EXECU	DITCH	Edge of road, rocky gravel			Couldn't see road well.	
43	0230					HEMTT M985	PVS-7B	NODET	VEH REAR	HMMWV on right front			Blinded by flashlight, couldn't see HMMWV.	Yes

No.	Local Time	Environment: Rain	Fog	Smoke	Dust	Type of Vehicle	Type of NVD	Type of Error	Obstruction	Type/Position of Obstacle	Size of Obstacle	Speed	Visual Problem	Bloom
44	2200					HMMWV M1025	PVS-5	NODET	DO	Void to right	10' D	5 mph	Could not see surroundings.	
45	2145					HMMWV M1025	PVS-5	NODET	PERS	Sleeping soldier, right front			Didn't see sleeping soldier.	
46	0155		X			HMMWV M1026	PVS-7B	NODET	DO	Gravel pit drop-off in front	15-18'		Didn't see pit/drop-off.	
47	2350	X				HMMWV M1026	PVS-7B	INSUF	DO	Culvert-type drop-off	10-15 ft.		Misjudged terrain.	
48	0110					HMMWV M1026	PVS-7B	AWMIS	SOIL	Edge of creekbed on right			Misjudged terrain.	
49	2215		X			HMMWV M1037	PVS-7	EXECU	DITCH	Ditch on right			Misjudged road.	
50	1800					HMMWV M1038	PVS-7B	AWMIS	STEEP	Incline		5 mph	Misjudged incline, rough terrain.	
51	2145	X				HMMWV M966	PVS-5	EXECU	DITCH	Shoulder, culvert to right		10-15 mph	Misjudged shoulder condition on right.	
52	0030			X	X	HMMWV M966	PVS-5	EXECU	DITCH	Ditch on right			Low light, dust, hood obscuration couldn't see ditch.	
53	0230					HMMWV M966	PVS-7B	NODET	DITCH	Steep sided rut	18" D		Didn't see rut until before impact.	
54	2230					HMMWV M966	PVS-7	AWMIS	DITCH	Washout			Lacked depth perception, misjudged clearance.	
55	2300					HMMWV M966	PVS-7	INSUF	DO	Right side of trail,			Misjudged road.	
56	0415				X	HMMWV M996	NVGs	EXECU	DITCH	Road edge on left		10-15 mph	Couldn't follow road.	
57	0200					HMMWV M996	PVS-7	INSUF	DO	Tank trap			Didn't avoid tank trap.	
58	1945				X	HMMWV M997A	PVS-7	NODET	DO	Wadi in front			Lost orientation.	
59	2200					HMMWV M998	PVS-5	DECIS	BR EDGE	Road, bridge edge on left			Blinded by on-coming headlights.	
60	0100					HMMWV M998	PVS-7B	AWMIS	DITCH	Incline to right	4' V		Misjudged clearance to incline.	
61	2330				X	HMMWV M998	PVS-5	AWMIS	DITCH	Drainage ditch		30 mph	Misjudged road.	
62	0200					HMMWV M998	PVS-7B	EXECU	DITCH	Ditch			Poor judgement of terrain.	
63	2020					HMMWV M998	PVS-7B	NODET	DITCH	Drainage or tank ditch			Couldn't see unmarked ditch.	
64	0220					HMMWV M998	PVS-5	AWMIS	DITCH	Embankment			Lack of adequate depth perception.	
65	0315					HMMWV M998	PVS-7	NODET	DITCH	Turn and ditch on tank trail			Blinded by lightning.	Yes
66	2045					HMMWV M998	PVS-5	NODET	DO	Fighting position in front			Didn't see old fighting position.	
67	2200					HMMWV M998	PVS-5, P	INSUF	DO	Tank trap in front	8' W x 4' D	15-25mph	Didn't see tank trap.	
68	0130					HMMWV M998	PVS-5	AWMIS	DO	Cliff in front	30 ft	5 mph	Mistook cliff for bump in road.	
69	2100					HMMWV M998	NVGs	NODET	DO	Tank ditch in front			Did not see tank ditch.	
70	0130					HMMWV M998	NVGs	INSUF	DO	Wadi or washout in front	15 ft		NVG problem, lost awareness of location.	
71	1930				X	HMMWV M998	PVS-7B	INSUF	DO	Tank ditch at left front	10' x 30' x 8'D	5 mph	Misjudged proximity or didn't see tank ditch.	
72	2215			X	X	HMMWV M998	NVGs	NODET	DO	Washout in front	6 - 9 ft		Missed turn, didn't see washout in time to avoid.	
73	2344					HMMWV M998	PVS-7	NODET	DO	Ledge, front left		3 mph	Depth perception, didn't see ledge, terrain seemed flat.	
74	2045					HMMWV M998	PVS-7B	NODET	DO	Cliff	45' D		Didn't realize proximity of cliff.	
75	0500					HMMWV M998	PVS-7	AWMIS	DO	BMP dug into ditch, right		5 mph	Misjudged road, ditch.	
76	2130					HMMWV M998	Yes	INSUF	DO	Drop-off beside road			Couldn't see side of tank trail.	
77	2400					HMMWV M998	PVS-7	INSUF	DO	Tank trap			Misjudged or didn't see tank trap.	
78	0430				X	HMMWV M998	PVS-7	NODET	DO	Wadi	3-4 ft.D		Misjudged severity of wadi.	
79	2115					HMMWV M998	PVS-7B	INSUF	DO	Wadi beside road		slow	Couldn't follow road.	
80	2340			X	X	HMMWV M998	PVS-7B	NODET	DO	Wadi	20 ft		Didn't see wadi.	
81	2341			X	X	HMMWV M998	PVS-7B	NODET	DO	Wadi	20 ft		Didn't see wadi.	
82	0500					HMMWV M998	NVGs	NODET	DO	Antimobility trench			Didn't recognize trench.	
83	1945	X				HMMWV M998	PVS-7B	NODET	HOLE	Washed-out hole			Became disoriented.	
84	0300				X	HMMWV M998	PVS-7A	NODET	LOW OBS	Culvert		very slow	Misjudged terrain, culvert.	
85	2000		X			HMMWV M998	PVS-5	NODET	PERS	Ground guide in front			Situation awareness.	
86	0500					HMMWV M998	NVGs	NODET	PERS	Soldier lying on ground			Didn't see sleeping soldiers.	

No.	Local Time	Environment				Type of Vehicle	Type of NVD	Type of Error	Obstruction	Type/Position of Obstacle	Size of Obstacle	Speed	Visual Problem	Bloom
		Rain	Fog	Smoke	Dust									
87	2100					HMMWV M998	PVS-7	NODET	PERS	Sleeping soldier			Didn't see soldier.	
88	0015		X		X	HMMWV M998	PVS-7	INSUF	R TERR	Rough terrain			Misjudged terrain.	
89	2030					HMMWV M998	PVS-5B	NODET	ROCK	Rock in front	"to big"	<10 mph	Didn't see rock.	
90	0545					HMMWV M998	PVS-7	NODET	ROCK	Large rocks in front	large	too fast	Lost place, didn't see rocks in time to stop.	
91	1920					HMMWV M998	PVS-7	EXECU	ROCK	Rocks			Didn't see, or misjudged size of, rocks.	
92	2100					HMMWV M998	NVGs	AWMIS	SAND	Hill in front, sand in rear			Misjudged terrain.	
93	2200					HMMWV M998	PVS-7B	EXECU	STEEP	Edge of slope at angle			Misjudged terrain/slope.	
94	0045					HMMWV M998	PVS-5	NODET	VEH REAR	M113 APC in front			Blinded by on-coming headlights.	Yes
95	2400					HMMWV NEC	PVS-7A	AWMIS	DITCH	Embankment ditch on left			Misjudged turn.	
96	2335					HMMWV NEC	PVS-7B	EXECU	DITCH	Embankment on right side			Likely washed-out NVGs, lost road.	
97	2200					HMMWV NEC	PVS-7B	NODET	DITCH	Washout covered by grass			Had no indication of washout.	
98	0330				X	HMMWV NEC	PVS-5	EXECU	ROCK	Rock, incline on right		15 mph	Misjudged situation.	
99	2120					Howitzer M109	NVGs	AWMIS	SOIL	Wadi on right side		stopped	Misjudged integrity of soil.	
100	2150				X	Howitzer M109A2	PVS-7	EXECU	SHALLOW	Dip in front			Mistook dip for a sharp drop off.	
101	2100					LAV 25	VVS-2	DECIS	LOW OBS	Concrete culvert on left			Blinded by oncoming lights, lost road.	Yes
102	0200					motorcycle	PVS-5	NODET	DITCH	Washout in road			Didn't see obstacle.	
103	2300					Motorcycle	PVS-7A	NODET	HIGH OBS	Runway marker sign, front	16" G		Didn't see sign.	Yes
104	2400					motorcycle	PVS-7	DECIS	RISE	Rise in front	3 ft.	10 mph	Not looking in proper direction.	
105	2240					NEC Gov Veh	PVS-7	INSUF	MANEUVER	Trail, small ridge			Misjudged terrain.	
106	0030					Tank M1	NVD	NODET	DO	Small cliff/drop-off in front	small		Poor depth perception, couldn't see terrain well.	
107	2000					Tank M1	VVS-2	NODET	DO	Bank, ditch	29 ft. D		Couldn't see.	
108	2130					Tank M1	NVD	NODET	DO	Hole, old fighting position			NVDs washed out, didn't see hole.	Yes
109	1905					Tank M1	VVS-2	NODET	LOW OBS	M8 alarm			Didn't see alarm.	
110	0415					Tank M1	VVS-2	EXECU	SOIL	Ravine embankment, right			Misjudged maneuvering room, proximity to right ravine.	
111	2100			X	X	Tank M1	NVDs	NODET	VEH REAR	2.5 ton truck front left		10-15mph each	Couldn't follow lane.	
112	0330				X	Tank M1	PVS-7	DECIS	VEH REAR	Right rear Q of M1		15 closing	Didn't see rear of M1 until too late.	
113	2130					Tank M1	NVD	NODET	DITCH	Ditch			Driver's sight washed out, didn't see ditch.	Yes
114	2305					Tank M1	NVD	NODET	DO	Grass covered hole in front		10 mph	Misjudged terrain.	
115	2000					Tank M1	VVS-2	NODET	DO	Bank, ditch	29 ft. D		Couldn't see, wasn't using ground guide.	
116	0415					Tank M1	VVS-2	NODET	DO	Embankment, edge of wadi		2-3 mph	Misjudged terrain, didn't see wadi.	
117	2400					Tank M1	PVS-7	INSUF	STEEP	Rut in front		slow	Misjudged severity of terrain.	
118	1920					Tank M1/M1IP	VVS-2	SUD	DITCH	Ditch/shoulder on right			Misjudged shoulder integrity.	Yes
119	2200					Tank M1/M1IP	VVS-2	AWMIS	STEEP	Incline			Perception of terrain.	
120	2145					Tank M1/M1IP	PVS-7	EXECU	VEH REAR	Tank in front			Didn't see in time to stop.	
121	0645					Tank M11P	NVGs	NODET	DO	River bed, left front	10' embank.		Didn't observe drop-off of river bed.	
122	2100					Tank M1A1	NVGs	AWMIS	DITCH	Ditch		5-8 mph	Misjudged road.	
123	0230	X				Tank M1A1	Yes	NODET	DO	Tank fighting position at left		1-2 mph	Couldn't see tank fighting position, w/o spoil, from side.	
124	2200					Tank M1A1	PVS-7B	DECIS	DO	Roadside embankment			Sights washed-out by bright lights.	Yes
125	0055			X	X	Tank M1A1	VVS-2	EXECU	RISE	Berm in front			Sight went off, could not see turn in road.	
126	2330	X				Tank M1A1	NVGs	NODET	WATER	Water hole in front			Couldn't distingusih between ground and water.	
127	0215					Tank M1A1	VVS-2	EXECU	DITCH	Left shoulder			Judging left shoulder of road.	
128	2220					Tank M1A1	VVS-2	NODET	DO	BFV position low in front	10 ft D	5 mph	Didn't see hole.	
129	0500			X	X	Tank M1A1	PVS-7B	INSUF	DO	Prepared fighting position			Misjudged proximity of fighting position.	

No.	Local Time	Environment				Type of Vehicle	Type of NVD	Type of Error	Obstruction	Type/Position of Obstacle	Size of Obstacle	Speed	Visual Problem	Bloom
		Rain	Fog	Smoke	Dust									
130	2145					Tank M1A1	VVS-2	NODET	DO	Fighting position on right		5 mph	Didn't see obstacle.	
131	0130					Tank M1A1	VVS-2	NODET	DO	Battle position			Couldn't see battle position.	
132	2331				X	Tank M1A1	PVS-7	NODET	VEH FR	HMMWV			Misjudged safe separation from on-coming traffic.	
133	0100					Tank M1A1	VVS-2	NODET	VEH REAR	M1A1 tank			Didn't see each other, partially blinded by service lights.	
134	0330					Tank M551	PVS-7A	INSUF	DO	Wadi at side	9' D		Didn't see wadi.	
135	2115					Tank M551 ARV	PVS-7A	AWMIS	DITCH	Wadi (?)			Apparently didn't see tank trail in wadi.	
136	2030				X	Tank M60	PVS-7B	NODET	ROCK	Rock right front	large		Didn't see rock in time to avoid.	
137	2100					Tank M60A3	NVD	NODET	DO	Tank ditch		5-10 mph	Difficult seeing terrain, poor depth perception.	
138	2310					Tank M60A3	VVS-2	NODET	WIRE	Guy wire at left front			Didn't see guy wire.	
139	0500					Truck M151A2	NVD	NODET	DO	"Cliff"	15 ft.	1-4 mph	Couldn't follow trail.	
140	0030					Truck M151A2	NVGs	NODET	VEH REAR	HEMTT NEC		reasonable	Distorted depth perception.	
141	2345			X	X	Truck M35A2	NVG	EXECU	DITCH	Edge of road on front left			Couldn't see in dustout.	
142	530					TruckM35A2	PVS-7	INSUF	DO	Wadi in front			Not specified.	
143	2030	X				TruckM35A2C	NVG	EXECU	DITCH	Road edge on right			Misjudged shoulder.	
144	1845				X	TruckM109	NVGs	INSUF	RISE	Incline on left		5-10 mph	Misjudged terrain and clearance on left.	
145	0100			X	X	Truck 5 ton	PVS-7A	INSUF	DITCH	Shoulder, ditch on right	4 ft.		Fatigue.	
146	0230				X	Truck 5 ton	PVS-7	DECIS	DITCH	Shoulder of road			Lost visibility due to dust.	
147	2300					Truck 5 ton	PVS-7B	DECIS	VEH REAR	5 ton TPU in front		30 mph	Didn't see obstacle in time to stop.	
148	0300		X			Truck M54A2	PVS-5	EXECU	STEEP	Steep bank up on left			NVGs fogging, misjudged curve.	
149	2000					Truck M923	PVS-7B	INSUF	DITCH	Left side of road			Couldn't see well enough to drive safely.	
150	1915		X			Truck M923	PVS-7	AWMIS	STEEP	Shoulder on left	30' embmt		Very poor visibility, couldn't follow road.	
151	1830	X	X			Truck 5 M923	NVGs	EXECU	VEH REAR	M1037 HMMWV		15 mph	Couldn't see in time to avoid obstacle.	
152	0025					Truck M923A1	PVS-5C	EXECU	MANEUVER	Embankment			Misjudged curve.	
153	0030					Truck M931	PVS-7B	EXECU	DITCH	Ditch on side of road			Lost site of lead vehicle.	
154	2130				X	Truck M931	PVS-7B	NODET	VEH REAR	Tractor trailer in front		12-15 mph	Didn't see obstacle in time to stop.	
155	0445				X	Truck M931A2	PVS-5	AWMIS	DITCH	Wadi at left			Didn't see wadi or misjudged road.	
156	0130				X	Truck M931A2	PVS-7B	AWMIS	DITCH	Shoulder			Misjudged road.	
157	0420				X	Truck M931A2	PVS-5	AWMIS	ROCK	Left front roadside, rock			Misjudged road.	
158	0300					Truck cargo	PVS-5	NODET	PERS	Soldier lying prone			NVGs washed out, didn't see soldier's leg.	Yes
159	2200					Truck Cargo	PVS-5	AWMIS	SOIL	Road edge, shoulder			Misjudged closeness to edge of road.	
160	0400					Truck NEC	PVS-7	NODET	PERS	Men lying on tarmac			Couldn't see well in conditions of blooming.	Yes

APPENDIX B

EXPANDED TRAINING TOPICS LESSON OUTLINE

I. Introduction
    A. Concept of "Own the Night"
    B. Why do we use night vision devices
    C. Capabilities
    D. Image intensification (I^2) versus infrared (IR)

II. Types of I^2 Systems
    A. Night vision goggles (NVGs)
        1. Head mounted
        2. Light weight
        3. Relatively inexpensive
        4. Battery powered
    B. AN/PVS-7B NVGs
        1. Generation III tube
        2. Sensitive to visible light and near IR
        3. Single sensor with two displays (one for each eye)
    C. AN/PVS-5 NVGs
        1. Generation II tube
        2. Sensitive to visible light
        3. Two tubes and two displays
    D. Combat Vehicle-Mounted System
        1. Mounted in front of driver in place of forward periscope (vision block)
        2. Vehicle power with battery back-up
        3. Manually movable in azimuth and elevation
        4. AN/VVS-2 Driver's Night Vision Viewer
            a. Generation II tube
            b. Sensitive to visible light
            c. Single sensor with single display

III. I^2 Concepts
    A. How it works
        1. Light amplification
        2. Photocathode tube
    B. Eye response and effects compared to the I^2 system
    C. Effects in I^2 systems
        1. Provides you with the ability to see in the dark
        2. Display is shades of green
        3. Affected by environment, just like normal vision
        4. Acuity is about 20/40 at best
        5. Reduced FOV - 40°
        6. Depth perception is affected

7. Image blurs if head is moved rapidly
8. Depth of field is reduced - objects close to driver will be out of focus
9. Scintillation under very low light levels
10. Blooming
11. Washout
12. Loss of some 3D cues

IV. I^2 Hardware
- A. Lens system
- B. Fiber optics
- C. Ceramic detectors
- D. Eye piece
- E. Automatic gain control
- F. Helmet mount
- G. Adjustments
    1. Focus
    2. Diopter adjustment
    3. Interpupilary distance adjustment (IPD)
    4. Tilt
- H. Battery or power connector

V. I^2 Working Conditions
- A. Environments
- B. Dust
- C. Smoke and obscurants
- D. Fog
- E. Rain
- F. Snow
- G. Light levels
- H. Moon light
    1. Moon cycle and rise and set
    2. Quarter moon or greater is best
    3. Moon low on horizon or less than quarter moon - degrades image
    4. Cloud cover reduces available light
- I. Star light
- J. Artificial lights
    1. Cause blooming and reduced sensitivity
        - a. Own headlights (service drive lights)
        - b. Other vehicle headlights
        - c. Street lamps
        - d. Flashlights
        - e. Lightning
        - f. Flares
    2. Distance is difficult to judge

VI. Vehicle Conditions
   A. Lighting (Internal)
   B. Lighting (External)
      1. Black-out drive can provide additional lighting under low illumination conditions
      2. Black-out marker lights can aid in tracking other vehicles in a convoy
      3. Four-way flashers will severely degrade the NVGs and blind oncoming or following vehicles using NVGs
   C. Speed (reaction times)
   D. Road conditions

VII. I^2 Driving Specifics
   A. Driving with NVGs is a skill - maintain proficiency with practice
   B. Training
      1. AR 600-55 requires completion of a training program to drive with NVGs
      2. DA Form 348 must have the proper entry
      3. Refresher training if have not driven with NVDs within six months
   C. Obstacle Detection
      1. Man-made objects have harsher edges
      2. Man-made objects usually have geometric shapes
      3. Use edge of road and tracks of other vehicles as guide
      4. Detection of roadside ditches and drop-offs is difficult
      5. Relationship between detection distance and vehicle speed
   D. Scan to compensate for reduced FOV
   E. Distance estimates will be affected
   F. Estimates of gaps between objects will be affected
   G. Contrasts
   H. Moving shapes
   I. Shape recognition
   J. Keeping aware of surroundings

VIII. Preparing for a Mission
   A. Night vision equipment check
      1. Proper maintenance of night vision device
      2. General condition
      3. Clean lenses
      4. Battery check and installation

5. Adjustments
    a. Focus (Critical)
        1. Objective lens
        2. Diopter
        3. Use a target with straight edges and writing as a focus target
    b. Interpupilary Distance
    c. Mounting
    d. Eye relief
    e. IR illuminator off

B. Vehicle check
    1. Blackout (BO) drive
    2. BO marker
    3. Use of interior lights - red lights will reduce the effectiveness of the NVGs
    4. Warning lights - tape over to avoid sudden illumination that will shut down the NVGs (small hole in tape will allow the light to be seen if the warning comes on)
    5. Windshield cleanliness

C. Environment check
    1. Moon illumination and moon rise/set
    2. Cloud cover

D. Route check
    1. Map reconnaissance
    2. Type of terrain
    3. Information on condition of roadway or terrain
    4. Information on terrain hazards (wadi, ditch, fighting position, cliff, etc.)
    5. Recent weather (heavy rain, etc.) that may affect the terrain
    6. Probability that path will have obstacles

E. Crew briefing

IX. Conducting a Mission

A. Single vehicle

B. Convoy
    1. Use BO marker lights
    2. Use BO drive lights if moon illumination is low
    3. Know convoy speed and catch-up speed
    4. Know procedures if contact with leading vehicle is lost

C. Crew Coordination
    1. Crew briefing
    2. Crew communication
    3. Assistant driver aids in obstacle detection
    4. Method for assistant driver to announce hazard or unsafe condition
    5. Dismount procedures when using NVGs

D. Use of ground guide
    1. Keep ground guide in sight at all times
    2. Do not move vehicle unless you are certain where the ground guide is
E. Keep NVGs on - don't hand hold like binoculars while driving
F. Scan
    1. Scan the environment to compensate for reduced field of view
    2. Scan in the direction of the vehicle path and only occasionally close in to observe variations in terrain
G. Maintain NVG focus - if focus ring gets bumped, stop to check focus
H. Adjust speed for conditions
I. Emergency procedures
    1. NVG or tube failure, or
    2. Wash-out from external lights, or
    3. Uncertain terrain features to side or front, or
    4. Loss of vision due to dust, smoke, or obscurant
        a. Stop vehicle as quickly and as safely as possible
        b. Steer in the direction where you know the pavement or terrain to be clear of obstacles
        c. Do not pull over to the side of the road unless you are certain of the terrain. Roadside ditches can cause a rollover!
    5. Vehicle stopped on roadway - keep BO marker lights on or provide for other NVG compatible light source so that other vehicles can see you

X. Driving Hazards
A. Drop-offs (greater than 3 feet in depth) - greatest hazard
B. Ditches (less than 3 feet in depth)
C. Vehicles on or near roadway
D. Steep grades
E. Personnel
    1. Sleeping or lying on ground
    2. Standing on or near road
    3. Ground guide too close to vehicle (always keep ground guide in FOV)
F. Rise in terrain
G. Large rock in vehicle path

XI. Driving Errors
A. Lack of detection of obstacles (mainly drop-offs and ditches)
B. Aware of obstacle, but misjudged distance, clearance, or characteristics (depth, width)
C. Poor decision regarding how to approach or avoid obstacle
D. Poor execution of plan to approach or avoid obstacle

XII. I^2 Driving Simulation

A. Simulated conditions (set or random, controls move simulation by driver)

B. Examples

1. Simulated conditions
    a. low light
    b. bright light
    c. change in light (sudden/gradual)
2. Simulated predicaments
3. Simulated driving
    a. video shots
    b. stills

APPENDIX C

SAMPLE CONCEPT DEVELOPMENT TOOL SCENARIOS

C.1. Purpose

We developed four preliminary lessons as part of the Night Driving Training Aid project to test out some theories of how best to present information to the trainee. Development and implementation of these lessons had a two fold purpose: (1) to examine different ways that material may be presented to the trainee, and (2) to determine what capabilities will need to be changed in the Concept Development Tool to produce the NDTA.

C.2. Development

The Concept Development Tool was a spin-off of another trainer, the "FLIR Training Aid", DCS developed under a different SBIR. The "FLIR Training Aid" was produced as a point and click style trainer, the understanding at the time was that the trainee would need to go at his/her pace through the lessons. Originally implemented as a primary augmentation to a training course and as a refresher trainer, the "FLIR Training Aid" was designed and developed using modular software development techniques. One of the internal goals during its development was to develop a trainer which could be modified to train any subject area, was modular enough to be able to easily upgrade, and was simple enough to integrate that subject development would not require the use of a programmer. The Concept Development Tool capitalized on the modularity in that lessons could quickly be added and modified as necessary.

Screen prints of the lessons from the Concept Development Tool are presented below, along with an explanation of what was being attempted with the lesson. Note that the layout for all but the last screen have an introductory paragraph, a concept field (for displaying lesson concepts in sequence for the trainee to read), a "down" arrow (to allow the trainee to continue at his/her own pace), a play stage area (for showing video and images), and a command line at the top (for navigation within the trainer).

C.2.1. "Example Video" Lesson Screen

The "Example Video" lesson screen (shown as Figure C-1) was developed to explore the addition of .AVI files in the trainer. The original "FLIR Training Aid" had the capability of running .AVI files but without providing for specific portions of the file to be played. In addition the original "FLIR Training Aid" did not provide for a VCR-like control panel so that the trainee could replay the video at will. The goals of placing this lesson into the Concept Development Tool were to explore problems associated with display of video and modifications required to the basic trainer to implement some basic ideas. The approach was to:

- develop a lesson in which a video is first shown in its entirety,
- followed by backing up the video to show specific features,
- show a still of the feature with a bounding box overlaying the area of concentration,
- continue on with the video, and
- finally display the VCR-like control panel to let the trainee go back and forth in the video.

Several problems presented themselves in the development of this lesson. The first problem was to add the capability to play only a specific portion of the video. This was a simple modification to the command syntax to call specific underlying Windows MCI routines to perform the function. The second problem showed itself because of the overlay nature of playing videos under Windows. The video itself is always the foremost window in the system and no other items can overlay it. A work around to this problem would be to play the portion of the video, then display a still bitmap (which in turn can have a box overlaying it) then, upon activation by the user, continue on by playing the rest of the video to the user. The problem with this work around is that the .AVI file (of about 18 Mbytes) is read in twice (the "FLIR Training Aid" trainer implements clip files dynamically). This will result in long delays in the presentation.

For a Phase II development effort, multiple clip files and/or multiplexing of .AVI files will need to be examined as alternatives in order to speed the presentation to the trainee. A third problem presented itself in that the .AVI file that was used in this lesson was frame grabbed at 320 x 240 from an I^2 video. The display on the "Play Stage" is at the same 320 x 240 image. It would be preferable to have a larger movie showing. This could be accommodated by forcing the "Play Stage" to be larger, although a X2 resolution of 640 x 80 pixels would cause part of the video to display off-screen in the normal 1024 x 68 resolution of the trainer. A mid size could be accommodated but pixel shift will occur and may provide false visual cues to the trainee. More exploration of this problem, including other presentation styles, will be done in a Phase II effort.

C.2.2. "Night Driving Hazards" Lesson Screens

The objective in the "Night Driving Hazards" lesson was to examine some general timing and display ideas. The first "Night Driving Hazards" lesson screen (shown as Figure C-2) shows a simple use of a first concept paragraph with an accompanying textual image listing several main driving hazards. The idea was to present several points in the concept field with the textual image being displayed. When those points were exhausted, an image detailing a hazard would be shown (in Figure C-3) along with a timed set of concept paragraphs. The concept paragraphs are shown in sequence with a defined number of seconds before the next one appears. The idea is to give the trainee enough time to read one paragraph before the next one appears. A "down" arrow appears at the end of the sequence for the slow trainees to continue on with the lesson as they catch up. Note that this is all one lesson with one display of the part that is currently being discussed. In the Phase II effort a more careful rendering of the final image will be

made. In the last screen (shown as Figure C-4) an image taken from a VVS-2 video is displayed along with accompanying concept text. Sound is a capability of the trainer but was not used in the Concept Development Tool. No new information was gained by implementing the "Night Driving Hazards" lesson.

C.2.3. "Using Image Cues To Detect Depressions" Lesson Screens

The objective in the "Using Image Cues To Detect Depressions" lesson was to examine the use of real and synthetic images together. The first "Using Image Cues To Detect Depressions" Lesson screen (shown as Figure C-5) shows an image of reflection from a puddle taken from a VVS-2 video screen shot. The second lesson screen (shown as Figure C-6) shows a synthetic image. This image was taken in daylight, converted to a gray scale, modified by a gamma correction, and converted to a green image (red and blue components of the gray were eliminated). This technique approximates the display of an I^2 device. Note that the image could have been made more realistic by adding shot noise. The only reason to use such a technique for the images would be in the case of a lack of available imagery. In those cases a judgment call would have to be made by someone familiar with the look of the device at the needed environmental constraints. Not all daylight pictures could be used, especially if moonlight shading is needed. Use of synthetic images was judged to be "good enough" to get the point across in several instances even though they were only approximations of the real thing. If specific types of images were not available during Phase II development, this technique would provide a means to get the required images into the trainer.

C.2.4 "NDTA Static Simulation" Lesson Screen

One of the more critical items in the development of the Night Driving Simulator is the simulation of Image Intensifier imagery given specific environmental constraints. Development of a "moving" image was clearly outside of the scope of effort for Phase I, but development of some of the basic algorithms was not. The "NDTA Static Simulation" was a special case simulation in that we were attempting to imitate the resulting image from an Image Intensifier device given certain environmental and physical constraints. The desire was to have a simple equation in which a base image pixel (with one of a set of 256 level gray shades), and parameters representing the environmental conditions could be turned into a resulting pixel which would represent what the user would see through the I^2 eyepiece.

In order to accomplish this task, the CRANE Intensifier Performance Model (CRANEIPM), developed by DCS for NSWC/CRANE, was used in several "runs" with some 30 parameters fixed for a given I^2 device. The results of the "runs" were used to statistically determine an equation of fit. This equation gave Output brightness (footLamberts) as a function of Sky Brightness (footLamberts), Visibility (km), Range from target (km), and Target Reflectivity (dimensionless). The sky brightness was a function of the amount of light incident on the target (moonlight, clear starlight, etc.). The target reflectivity was a function of the input base image pixel grayscale level. The

output brightness is then modified by an autogain offset equation representing the autogain function of the I^2 device under different sky brightness values. The resulting output brightness can then be converted back to a grayscale pixel value for use in the output scene. The way that this was implemented in the "NDTA Static Simulation" lesson screen was to modify the image palette according to the results of the equation on the palette indices. This had the appearance to the user of an almost instantaneous change to the scene when the input parameters were changed. This screen is shown in Figure C-7. This equation is very important to the Phase II effort because the underlying "moving" scene can be made to look like the scene through an I^2 device by adapting this equation to the scene palette.

The process that will be used in Phase II to provide a moving simulation will be to build a Virtual Reality Modeling Language (VRML) player. A VRML definition of the scene is analyzed by a VRML parser and converted to image objects. Those objects are then drawn in OpenGL® view space by a command engine whose job is to draw/display the scene and then change the point of view in the scene based upon the trainee inputs.

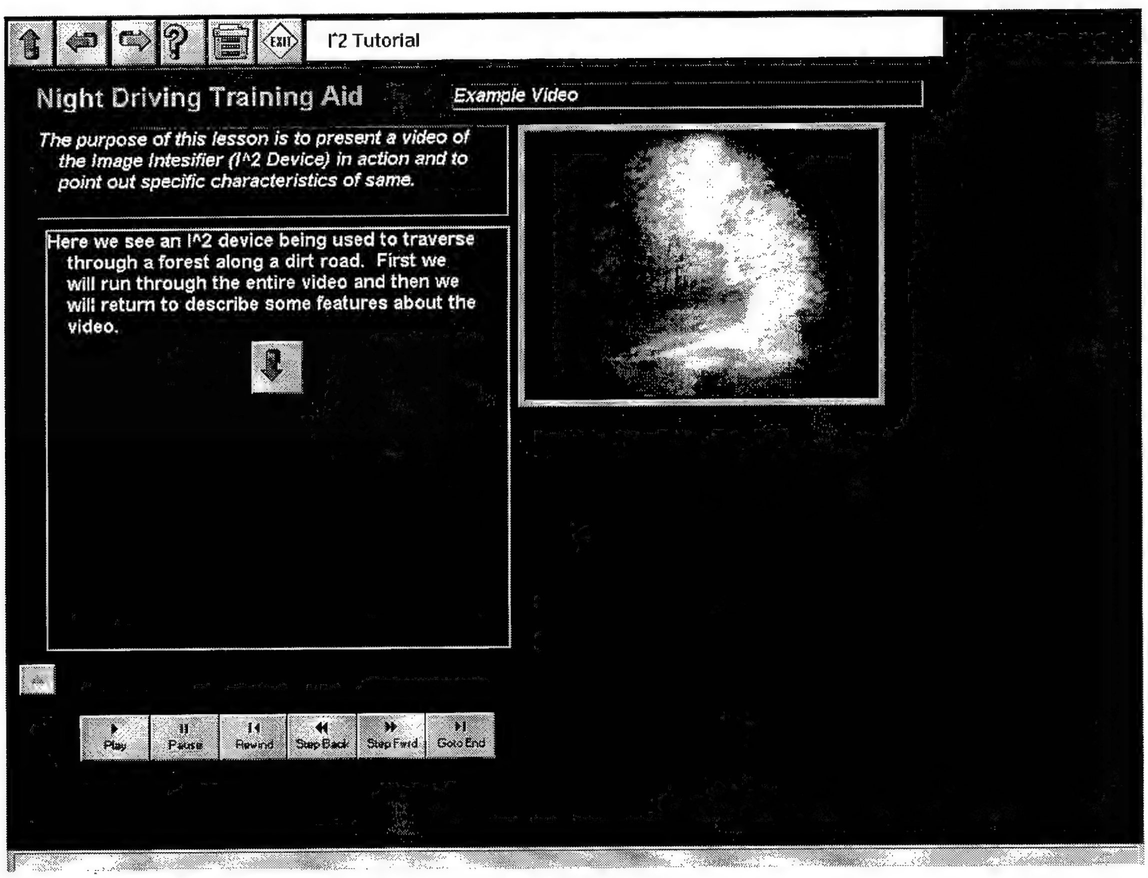

Figure C-1. "Example Video" Lesson Screen.

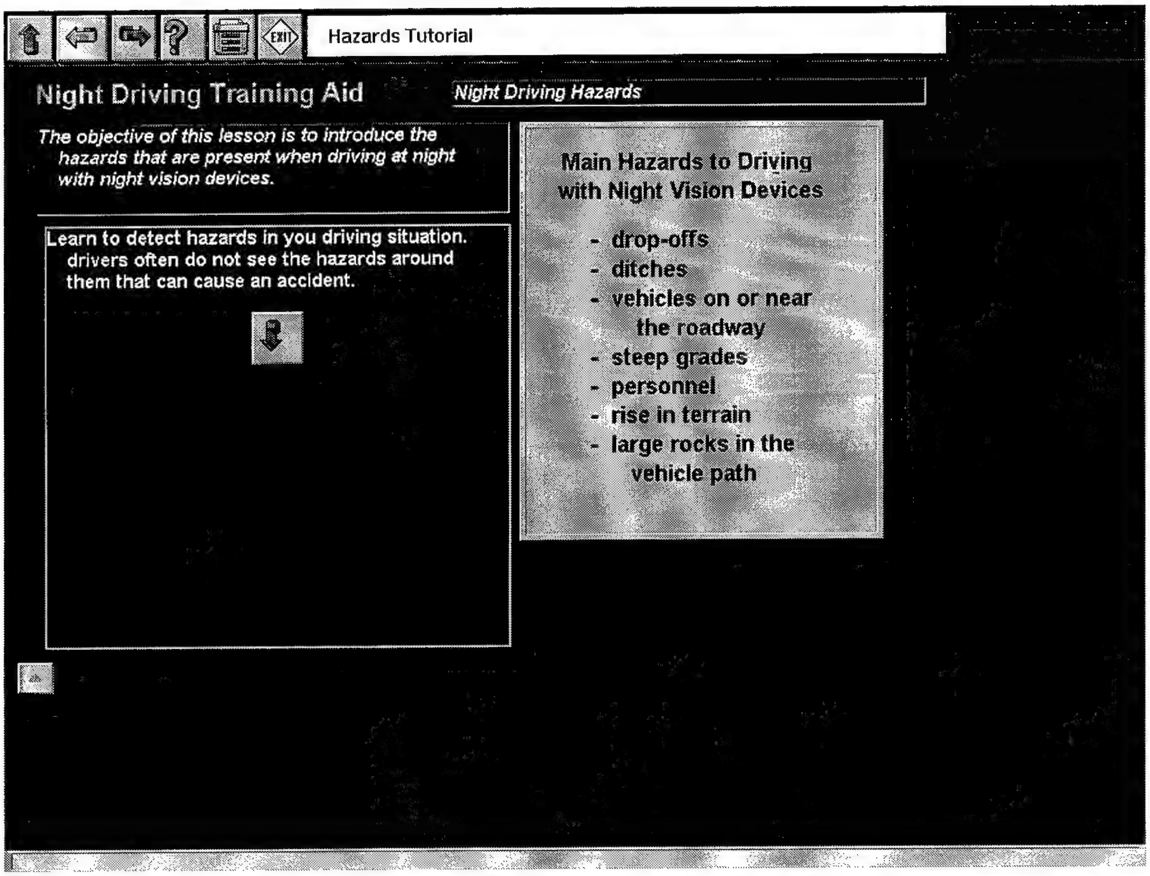

Figure C-2. "Night Driving Hazards" Lesson Screen 1.

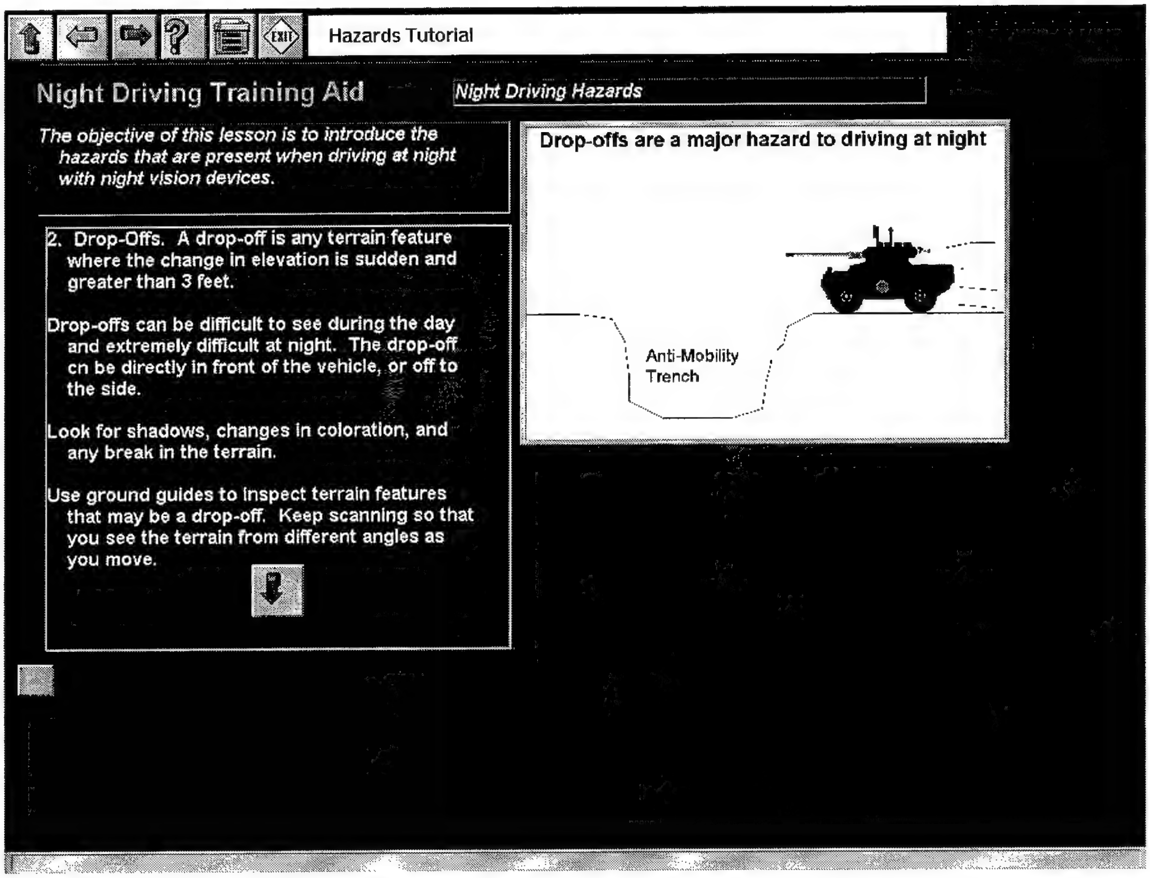

Figure C-3. "Night Driving Hazards" Lesson Screen 2.

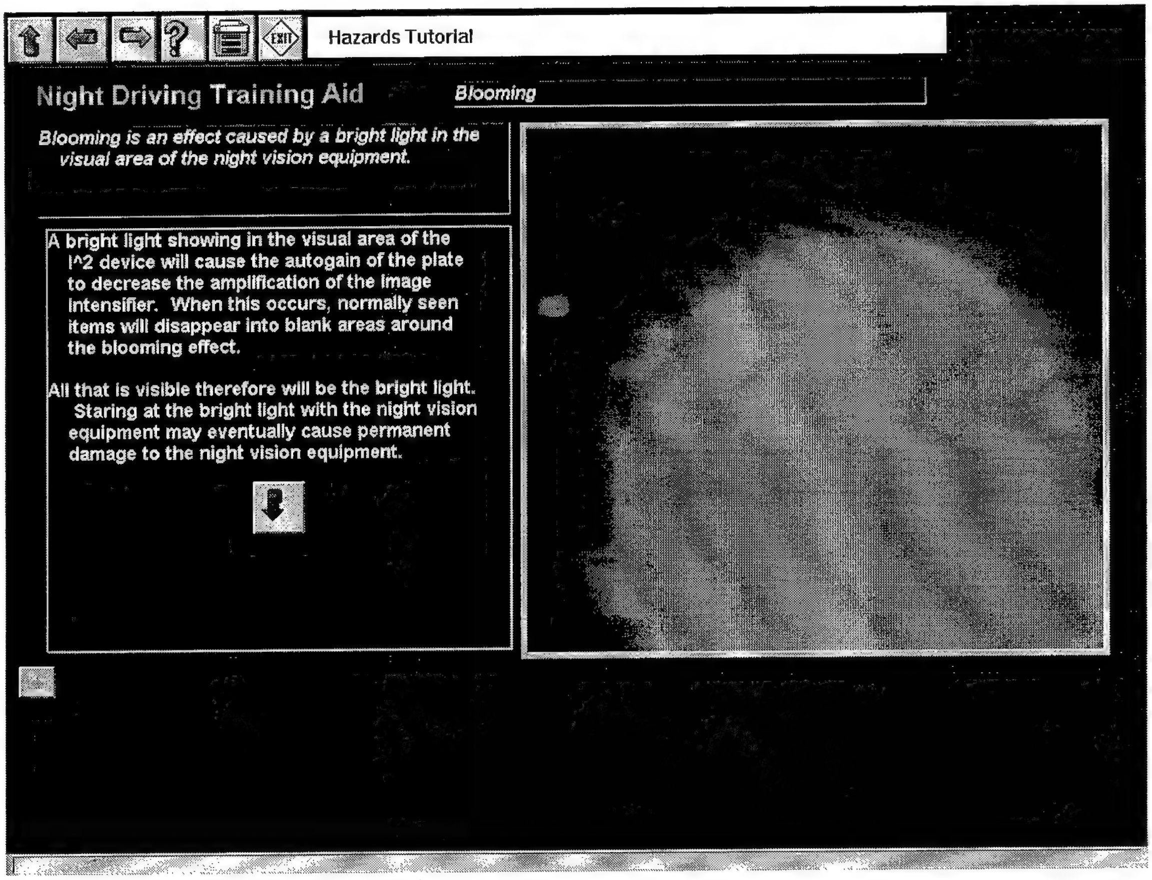

Figure C-4. "Night Driving Hazards" Lesson Screen 3 (Blooming).

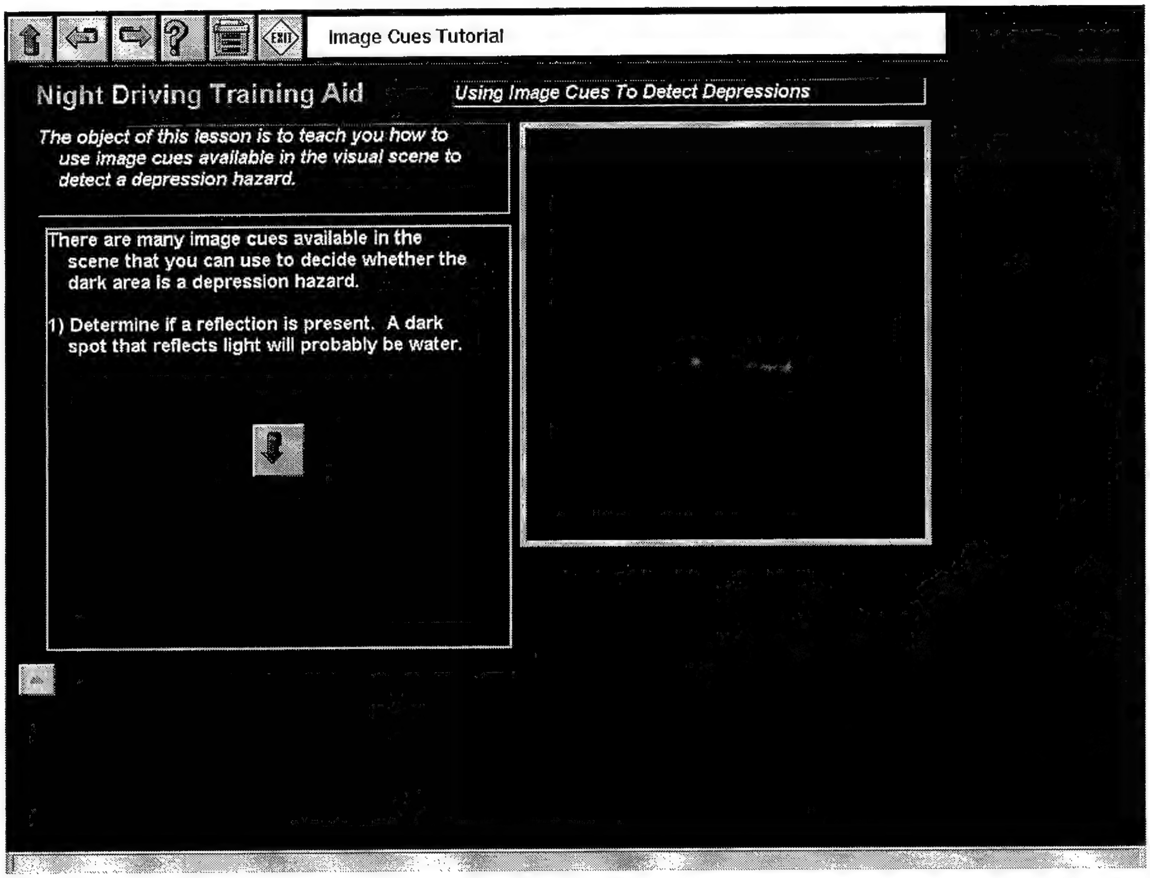

Figure C-5. "Using Image Cues To Detect Depressions" Lesson Screen 1.

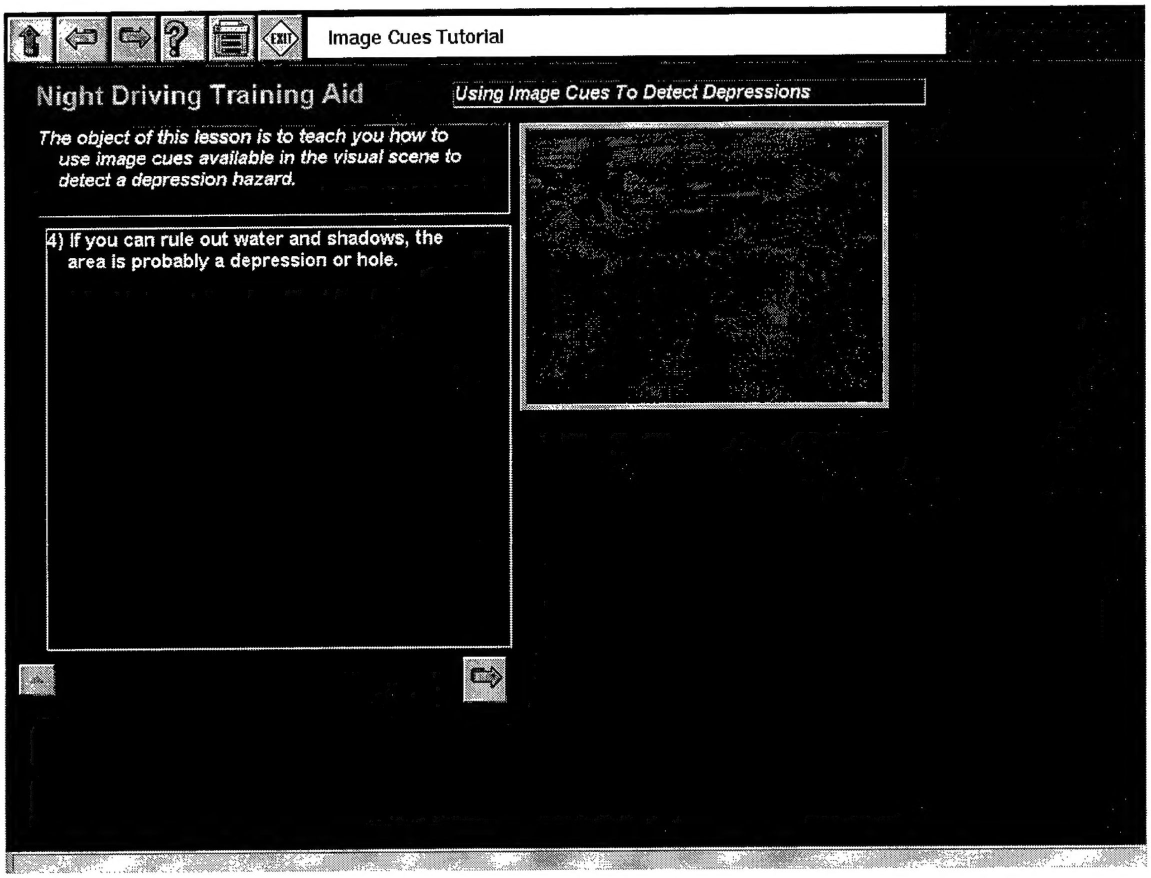

Figure C-6. "Using Image Cues To Detect Depressions" Lesson Screen 2.

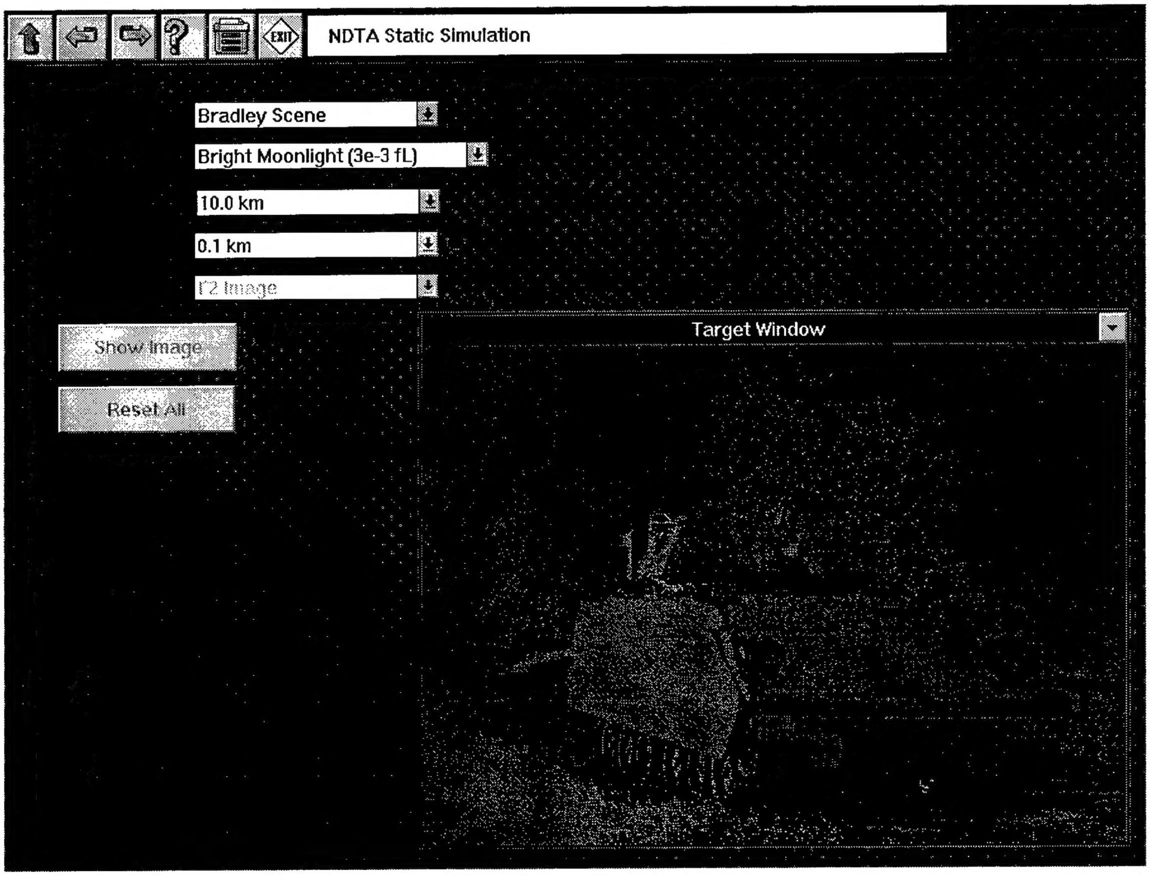

Figure C-7. “NDTA Static Simulation” Lesson Screen.

APPENDIX D

SYSTEM DESIGN

In the course of this Phase I SBIR effort, we explored different software and hardware architectures and investigated various hardware options available for the development of the NDTA. Our primary objective was to generate several alternative architectures for evaluation and to examine the general layout of the hardware/software. Figure D-1 describes the hardware interfaces and software interfaces for various envisioned components of the NDTA. The components in Figure D-1 constitute a preliminary generic system design for the NDTA and are discussed in detail in the following paragraphs. The preliminary system design will be expanded as part of the Phase II effort.

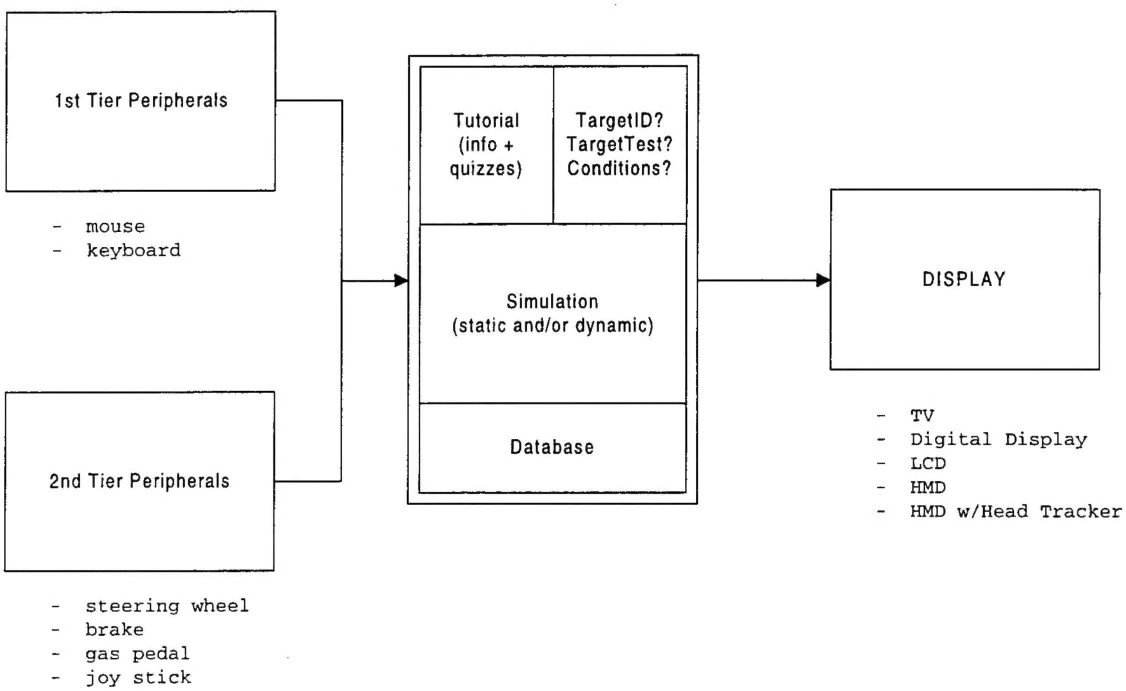

Figure D-1. Preliminary system design (conceptual hardware/software architecture).

The peripherals can be categorized into two tiers, or levels. First tier peripherals are those which are essential for controlling the selections within the NDTA. Examples of 1st tier peripherals are a mouse and keyboard. Second tier peripherals give more functionality and potential realism to the NDTA. Examples of 2nd tier peripherals are a steering wheel, gas pedal, brake, and joystick which provide the user with a "look and feel" environment to judge their reaction times and to provide at least a partial immersion into the night driving scenario.

The software architecture in the computer (the central box in Figure D-1) indicates the types of functionality that might be used to train the individual and to

measure and evaluate their performance. The tutorial section would provide information and quizzes to the user to train on various aspects of I^2 equipment theory, the theory of operations, the use of the equipment, the environment to expect, and appropriate and inappropriate techniques for driving with NVDs. There may be a need for target identification in which the user is trained to recognize various targets under different conditions. A target test could be implemented in which the user would be tested on his ability to recognize various targets in a timed manner.

A simulation section would need to be provided with static and possibly dynamic imagery. Static images provide a means of comparing and contrasting various conditions and the effects that they have on the scene being viewed, or comparing NVD imagery with visible imagery. Dynamic images provide a method by which the user can relate moving information to driving under night conditions. This moving information would include such items as moving shapes, contrast changes, etc. The suitability of a dynamic simulation versus a static simulation will depend on the particular skills to be trained. Dynamic simulations, although impressive in appearance, do not necessarily result in positive training except to show the user how to recognize hazards from moving image contrasts. Developing dynamic simulations is costly and must be justified by the expected gain in training benefits. However, both static and dynamic imagery may be appropriate depending on the skills to be trained.

A database section could be added to supply a means of tallying the users response to the quizzes and activities which could be used in later analysis of the NDTA effectiveness. The display may be of several types, each having advantages over the other. The TV/digital display/LCD monitors provide a standard presentation of the night driving imagery. An HMD can be used to provide a more immersive type of environment for training as the specific application warrants.